Key factors in the enabling environment for smallholder tree growing – experiences from the Global South

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ABSTRACT

Smallholder tree growing is drawing increasing attention as population and economic growth models anticipate increasing wood demand that current natural forest or industrial forest plantations will not be able to supply without endangering sustainable development goals. Furthermore, 'greening of economies' calls for substitution of non-renewable materials with renewables, such as cellulose-based products. This has led to increasing attention to smallholder tree growing and it's potential to contribute to the growing need for wood and ecosystem services from forests. Research on the motivations and drivers of smallholder tree growers and the role of smallholder tree growers in forest transition processes is available for some individual countries, and some qualitative analysis comparing countries on their enabling environments for smallholder tree growing has been done over the years. However, a systematic analysis with a global perspective is lacking.

This study contributes to understanding the role and combinations of contextual and sectoral factors in establishing an enabling environment for smallholder commercial tree growing in South-East Asia and Africa, and analyses the role and importance of incentives for smallholder tree growing. The dissertation consists of three articles (papers I, II, and III). Papers I and II are in-depth case studies from Tanzania and Lao PDR, and Paper III combines the case-studies with three additional country cases for a Qualitative Comparative Analysis.

Field research for the first and second paper collected data on household socioeconomic background and past, present, and future tree growing interests and practices through semi-structured interviews. Four villages in Njombe region in Tanzania, and four villages in central and northern Lao PDR were included in the study. In Tanzania, detailed information on smallholder plantation condition was collected through plantation inventories. The data collected was analysed using both qualitative and quantitative methods. For the third paper a theoretical framework was developed based on eight main factors in the enabling environment for smallholder tree growing identified in previous research. Country case-study information on these factors was collected through case studies on Tanzania and Laos, and desk studies on Indonesia, Uganda and Vietnam. Country case studies were then analysed using Qualitative Comparative Analysis applying a two-step approach and crisp set methodology. The analysis was run with *Tosmana* (Cronqvist, 2017) and verification of the results utilised *Kirq* (Reichert and Rubinson, 2014) and *QCA 3.0* software (Dusa, 2019).

Findings indicate that Tanzanian smallholder tree growers have strong interest to increase their tree growing area despite the weak enabling environment. In Lao PDR the smallholder teak growing area is not likely to expand as smallholders consider other land uses more attractive and the existing incentive framework fails to induce smallholder tree growing. Based on the Qualitative Comparative Analysis, secure land and forest tenure, and strong demand for timber may be sufficient to boost smallholder tree growing. However, functioning wood markets, knowledge, and direct incentives are present in the configurations in the majority of the cases, which especially seem to contribute in scaling up tree growing volumes and in building an enduring smallholder tree growing sector that is capable to maintain the tree growing activity and supply the wood markets. The role of incentives in smallholder tree growing varies in the case-study countries, but under strong market demand they may not even be necessary for plantation expansion if land tenure is clear. However, to be effective, incentives should be tailored to meet smallholder needs in a country-specific context, and adjusted according to the changing environment.

Secure land tenure and wood demand are essential elements in the enabling environment for smallholder tree growing. Even though they are not necessary for the initiation of smallholder tree growing, incentives play a crucial role in establishing technical knowledge and skills among smallholders to improve the quality of the wood they produce, which over the years has remained a challenge. However, incentives are only effective if they are designed from the beginning considering the smallholder capacities, actual needs, and their other livelihood options.

The findings confirm and highlight the importance of secure land and forest tenure recognized in multitudinous studies. Smallholder tree growers struggle to achieve the quality that higher value wood markets require, and their produce is sold mainly in lower value local or regional markets. This may still be a profitable business model and a way to diversify livelihoods from the smallholder perspective, but on the other hand it does not allow smallholder tree growers to reach their full production potential and profits, nor does it support the development of the wood industry. The findings also suggest that models and incentives improving smallholder access to land are an effective incentive for smallholder tree growing when the land use is defined as a condition for the allocation.

If global and national policies seek increasing smallholder contributions in tree growing for wood production and climate change mitigation, the first priority

is to provide them access to land and secure land and tree tenure. Smallholder tree growing schemes should either recognize and accept the capacity and financial limitations smallholders have, or support schemes should be tailored to their specific needs and to the varying socioeconomic contexts.

Keywords: Smallholder tree growing; forest policy; legislation; wood markets; incentives; livelihood diversification; Qualitative Comparative Analysis; enabling factors; time series, tenure, demand

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PREFACE

In 2013 I took the decision to start my journey towards a Doctorate, along with my work as a consultant. At that time the tone of voices in global discourse was becoming more stringent calling for actions to combat climate change. This trend has only intensified over the years that I've been working on my research.

There are some 570 million farms worldwide, most of which are small and family-operated. Small farms manage about 12% and family farms about 75% of the world's agricultural land. Just imagine if all of them would engage in sustainable and well-designed tree growing activities - how massive would be the carbon sequestration potential, not to mention the other potential benefits of tree growing identified in research, such as combatting erosion and desertification, improving agricultural productivity, diversifying and increasing rural income and improving their resilience against climate change. But under what terms could smallholders do this, and what kind of support would be needed?

My hunger to learn more, dig deeper in research knowledge and challenge myself triggered the decision to start my doctoral studies, but I also had questions in my mind calling for answers. In my work in development cooperation I had seen smallholder farmers planting trees, some more successfully than others. Tree growing was starting to emerge in Eastern African countries, and I wanted answers to questions like: what makes the difference – when do smallholder farmers engage in tree growing and when does it become a sustainable livelihood activity for them? Today, I believe I have found some answers, but as could be expected, even more new questions arise in the process.

The journey was long, but I did not travel alone as many people have supported me in many ways in the ups and downs of my studies. First and foremost, I want to thank Dr Markku Kanninen, my Professor and Doctoral supervisor at the University of Helsinki, Viikki Tropical Resources Institute (VITRI), for his support throughout the process; from accepting me as a Doctoral student, helping me to develop a solid research and study plan, and pushing me through until the last moments of finalizing the work.

Special gratitude goes to Professor Maria Brockhaus who was always there for me to help with the methodology and giving her constructive comments that challenged me to turn myself from a consultant to a researcher. I'm also indebted to Dr Nicholas Hogarth for his invaluable comments and editorial

support for the manuscripts. Special thanks go also to Professor Anne Toppinen (HELSUS), Arttu Malkamäki, and Maarit Kallio for their contributions, comments and support in the process. Likewise, thank you for all the colleagues and friends at VITRI and in the Department of Forest Sciences at the University of Helsinki for being there, for laughing through the stressful moments and making these years a fun experience.

My special thanks go to the Private Forestry Programme in Tanzania (supported by the Ministry for Foreign Affairs of Finland), Mr Michael Hawkes, and Mr Sangito Sumari and the team of Forest Technicians for organizing and supporting the field work in Tanzania. I also thank Mr Pheng Sypaserd, Department of Forest Inspection; Mr Vansy Phengthajaim from the National University of Laos (NUoL); Mr Phonekham Siphommachanh, Australian Centre for International Agricultural Research (ACIAR); and Mr Sisuthone Oupaxayorvanh and Mr Souksompong Prixar from NUoL for their assistance and coordination during the field work in Laos. The field work in Laos was supported under the framework of the FoLAFI project (Forestry Higher Education Cooperation Between Laos and Finland), which was funded by the CIMO N-S-S (NORTH-SOUTH-SOUTH) program and coordinated by VITRI, University of Helsinki, in collaboration with NUoL. I also want to thank Mr Juho Penttilä and Mr Juho Pekka Anttila who joined me for the field work in Tanzania and Laos to work on their Master's thesis and were a great help and good company.

I am also indebted to Dr Thuy Pham, Mrs Dao Thi Linh Chi, Mrs Long Hoang Tuang, and Dr Ani Adiwinata Nawir from the Center for International Forestry Research (CIFOR), for supporting the data collection and for their comments, and Dr Somvang Phimmavong (NUoL), Dr Reuben Mwanakimbullah (Sokoine Agricultural University, Tanzania), and Mr Paul Jacovelli (Unique Forestry and land use GmbH, Germany) for their data review support. Special thanks go to Ms Nena Oana from the Central European University – your introduction to QCA and 'R' and clear, adjustable scrips made my life so much easier! There are also many people I cannot thank by name as the comments received from anonymous reviewers in the peer-review process significantly improved my manuscripts.

My gratitude goes also to my former supervisors and colleagues in Indufor for being flexible and understanding when I struggled to combine the work and studies.

But the greatest thanks go to my family, to Sami and my sons Oskari and Ilari for being supportive and patient for so many years while I gave so much attention to my studies which was out of the family time. I'm also grateful to my mother Tuula and mother in-law Ritva for being there and giving their helping hand for the family when I was travelling for my studies.

There are many people who would deserve to have this thesis dedicated to them, but I want to dedicate this work to those who are too often forgotten and neglected, and yet have the power to change the direction of human kind in their hands – the smallholder farmers and tree growers of the world. It is time for you to become visible and recognized.

Riihimäki, September 2020

Anne Arvola

LIST OF ORIGINAL PAPERS

This dissertation is based on the following original scientific papers:

I. Arvola, Anne; Anttila, Juho-Pekka; and Hogarth, Nicholas (2018). By accident or by design? Influence of government policies on drivers and barriers of smallholder teak growing in Lao PDR. *Forests, Trees and Livelihoods*, DOI: 10.1080/14728028.2018.1557082.

II. Arvola, Anne; Penttilä, Juho; Malkamäki, Arttu; and Toppinen, Anne (2019). Mapping the future market potential of timber from small-scale tree farmers: perspectives from the Southern Highlands in Tanzania. *Small-scale Forestry*; http://link.springer.com/article/10.1007/s11842-019-09414-8 .

III. Arvola, Anne; Brockhaus, Maria; Kallio, Maarit; Pham, Thu Thuy; Chi, Dao Thi Linh; Tuan, Hoang; Nawir, Ani Adiwinata; Phimmavong, Somvang; Mwamakimbullah, Reuben; and Jacovelli, Paul (2019). What drives smallholder tree growing? Enabling conditions in a changing policy environment. *Forest Policy and Economics,* https://doi.org/10.1016/j.forpol.2020.102173.

Anne Arvola developed the research idea and the field data collection methods. She collected the data for Tanzania together with a MSc student Juho Penttilä, and for Lao PDR with MSc student Juho-Pekka Anttila (papers I and II). Juho Penttilä was responsible for the analysis of the inventory data from Tanzania, and Juho-Pekka Anttila analysed the wood trade information from Lao PDR. Anne Arvola developed the data collection matrix for the country data collection and analysis (paper III), and the data was compiled with the support of Pham Thu Thuy, Dao Thi Linh Chi, and Hoang Tuan from the Center for International Forestry Research, Vietnam (CIFOR), and Ani Adiwinata Nawir from CIFOR Indonesia, Somvang Phimmavong from the National University of Laos, Reuben Mwamakimbullah from Sokoine Agricultural University in Tanzania, and Paul Jacovelli from UNIQUE forestry and land use GmbH (Uganda). Anne Arvola was responsible for developing the analysis methods, and the data analysis for all the papers (I-III).

LIST OF MAIN SYNONYMS AND ACRONYMS

CIFOR	Center for International Foresty Research
DAFO	District Agriculture and Forestry Office
DIRINC	direct incentives
fsQCA	Fuzzy-set Qualitative Comparative Analysis
ha	hectare
INDIRINC	indirect incentives
IPCC	Intergovernmental Panel on Climate Change
K&S	Kalimantan and Sumatra
KNOW	Capacity and knowledge
Lao PDR	Lao People's Democratic Republic
LPTP	Luang Prabang Teak Programme
LUPLA	Land-Use Planning and Land Allocation programme
MAF	Ministry of Agriculture and Forestry (Laos)
MAR	wood markets and pricing
MSc	Master of Science
NEG	Negative
PES	Payments for Ecosystem Services
PM	Prime Ministerial
POS	Positive
QCA	Qualitative Comparative Analysis
Rev.	Revised
SME	small-to-medium enterprise
SPGS	Sawlog Production Grant Scheme
TGA	Tree Growers' Association
TNZ	Tanzania
TZS	Tanzanian Shilling
UNCTAD	United Nations Conference on Trade and Development

USD	United States Dollar
UGA	Uganda
VNM	Vietnam

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1. Introduction

1.1. Smallholder tree growing in developing countries

The IPCC special report on the impacts of global warming of 1.5 °C (IPCC 2018) highlights the urgent need to cut down anthropogenic carbon emissions, not only to mitigate climate change but also to contribute towards meeting the Sustainable Development Goals. Climate change mitigation options in the land sector include increased efforts to reduce deforestation and forest degradation, and increase afforestation and reforestation. At the same time, the growing population increases demand for wood-based products. Governments, multinational agencies and development financiers are therefore turning their gaze towards smallholder producers who could have a remarkable role in solving this puzzle (Evans, 2009; Kröger, 2014; Levis et al., 2017; Wiersum, 2006), and also due to socioeconomic challenges associated with large-scale industrial tree plantations (Kröger, 2014; Malkamäki et al., 2018).

Definitions of smallholder tree growing and plantations vary, and are also country specific (Harrison and Herbohn, 2002). Farm forestry is another common term used along with smallholder forestry and tree growing. Smallholder tree growing may take various forms, from a few trees planted around homesteads or on agricultural fields and pastures, to monocultures for timber production covering tens or even hundreds of hectares. Species grown on smallholder plantations are mostly the same, often exotic species as in industrial timber plantations, with genera such as Acacia, Eucalyptus, Pinus, Gmelina and Teak (*Tectona grandis*) dominating. They are preferred due to their adaptability and tolerance to stress, particularly in marginal sites; perceived fast growth and high yield combined with easy marketability; availability of technological information and research on these species; and relatively easy access to (quality) germplasm (Snelder and Lasco, 2008).

Land tenure arrangements may also vary from private registered lands to leaseholds on community or government lands, but it is rare to find people investing in land without some security on their rights to the land and the crop on it (Cronkleton et al., 2017). Although critique against smallholder tree growing is scant compared to industrial plantations, problems such as elite capture inflict smallholder tree growing as well (Kröger, 2014; Sikor, 2012). The magnitude of smallholder tree plantations in the Global South – in terms of area – are not well known as they are mostly not registered, and individual woodlots are often too small to be accurately mapped with present remote sensing technologies (Mayers et al., 2016; Verdone, 2018). Smallholder

commercial tree growing in this study refers to small-scale plantations where timber is grown for commercial purposes, and which are owned by individual landholders or small cooperatives, supplying a range of markets from small-scale local operations to large-scale processors (Schirmer et al., 2016).

Several countries in Asia and particularly in Southeast Asia have invested in developing smallholder tree growing schemes in recent decades. In Eastern Africa governments have had less interest and resources to invest in smallholder tree growing, but nevertheless smallholders are increasingly establishing woodlots and small plantations for commercial tree growing.

1.2. Smallholder tree growing in Eastern Africa and Tanzania

In Eastern Africa trees have traditionally been part of agricultural and agroforestry systems and are grown around homesteads for fruits and other products (Warner, 1993). However, since the early 2000's tree growing has become increasingly a commercial livelihood activity as the regional wood demand has increased rapidly (Held et al., 2017; Lukumbuzya and Sianga, 2017) and the shrinking natural forest resources do not deliver sufficient wood for markets (Panwar et al., 2016; Payn et al., 2015). The scale of smallholder tree growing activities vary, as well as the context and support mechanisms, but for example in Ethiopia (Lemenih and Kassa, 2014), Tanzania (Mankinen et al., 2016), Kenya (Patel et al., 1995), and Uganda (Ofoegbu and Babalola, 2015), smallholder plantations have become a significant source of wood in domestic supply chains.

The majority of forest plantations in Tanzania were established in the 1970's and were mainly owned and managed by the government until the 2000's (Ngaga, 2011). Presently there are 19 government owned and managed forest plantations covering 82 000 ha (TNBS, 2015), the most significant being the Sao Hill Forest Project in the Southern Highlands. The rate of replanting in government plantations has not been sufficient to maintain the plantations' wood production capacity, which is expected to lead to a collapse in their wood supply by 2020, and regional sawmilling and pole production industries have increasingly started to establish their own plantations (Indufor, 2011).

Since the 1980's Tanzania has been introducing policy and institutional reforms to boost the country's economy. This has also included reforms to strengthen the private sector and its involvement in managing forest and plantation forest resources. In the National Forest Policy 1998, market orientation and decreasing government ownership were emphasized, and the

National Forest Programme in Tanzania (MNRT, 2001) identified privatization and the enhancement of the role of the private sector in forestry as one of the strategies for achieving the forest policy objectives. Resources to support modernization and development of private forestry, such as extension and financial incentives, described in the National Forest Programme have materialized mainly through donor supported programmes in recent years. These efforts were supported with the introduction of the Land Act and Village Land Act which gave villages and households stronger control over the lands they are managing.

A general statement in the National Forest Policy on promoting smallholder tree growing through improved extension services has only recently started to materialize through projects operating in the Southern Highlands of Tanzania. The scope of the support programmes in the Southern Highlands is well-founded, as during the last ten years smallholder tree growing has proliferated. The smallholder tree plantation area in the Southern Highlands is presently up to 150 000 ha and it already exceeds the area of large-scale government and company plantations (Mankinen et al., 2016). Smallholder plantations have become a significant source for the small-scale sawmilling industry feeding the domestic construction sector (Moore et al., 2016).

1.3. Smallholder tree growing in South-East Asia and Lao PDR

In Southeast Asia agricultural modernization, intensification and expansion - the so-called 'Green Revolution' - fuelled substantial land expansion in the last decades, but in reality two-thirds of agricultural land expansion has been due to permanent crops, mainly oil palm (Headey, 2016). The trend is now turning in countries reaching the middle-income class and facing forest resource scarcity. China and Vietnam have emphasized the importance of forests as wood and environmental service providers and have pursued the establishment of strong forest industries. As a part of their forest policy, both countries have strongly promoted smallholder tree growing. With strong governmental support, they have been able to establish a significant plantation forest resource (Gutiérrez Rodríguez et al., 2016; Midgley et al., 2017) and the change has been so significant that it is called the 'smallholder forest transition pathway' in the literature (Barbier et al., 2010; Sandewall et al., 2015)(Barbier et al., 2010; Sandewall et al., 2015). Also, in the Philippines (Martín, 2012) and India (Singh et al., 2017), smallholder tree growing has become an established practice and a significant source of wood and ecosystem services.

In the Lao PDR the government has promoted smallholder tree growing since the 1990's but the success is modest compared to neighbouring countries. The economic reforms and promotion of smallholder tree growing started in Lao PDR at the same time as in Vietnam in late 1980's and early 1990's with strengthening private land tenure and opening markets. Both governments applied a similar model of allocating degraded land for smallholders for tree growing, but the difference in results is tremendous. While Lao PDR has managed to establish some 50 000 ha of smallholder tree plantations mainly with teak (excluding rubber plantations), in Vietnam smallholder tree plantation area is estimated to be around 1.5 million, most being planted with Acacia. In addition to species choice, other differences in approach between the countries are the financial incentives and investments, which in Lao PDR have been negligible compared to loan programs and technical support services the government provided in Vietnam (Thuy et al., 2016; Wunder et al., 2005). In addition, the investments made in smallholder tree growing were supported with a rapid industrial development in Vietnam, including an export oriented forest industry (Meyfroidt and Lambin, 2008; Putzel et al., 2012).

1.4. Enabling environment for smallholder tree growing

Smallholder tree growing may have a significant, or even the main role in forest transition processes, i.e. in turning forest cover loss to increasing forest cover as countries develop socially and economically. The point in which the curve begins to rise is called 'forest transitions' in the theory originally developed by Mathers (1992). However, drivers of deforestation and forest recovery (or reforestation) are fundamentally different (Barbier et al., 2010). In China and Vietnam governments have implemented ambitious promotional policies to engage smallholder farmers in tree growing and wood production, leading to a forest transition which is called 'smallholder driven forest transition' in the literature (Cochard et al., 2017; Liu et al., 2017), but the transition could initially be called government-led as the government has used smallholder tree growing as a vehicle to forest transition (Andoh and Lee, 2018; Meyfroidt and Lambin, 2009). However smallholders will only engage in tree growing if perceptions of the expected benefits of tree growing outweigh the risks and costs (Bebbington, 1999; Byron, 2001; Matthies and Karimov, 2014; Sandewall et al., 2015; Versteeg et al., 2017). The expected benefits depend on the smallholders' operating environment - i.e. social, economic, political, legal and institutional factors (Lamb, 2015) - or enabling environment. Based on the findings in consumer behavioural science, the operating environment is likely to influence the subjective perceptions and

forecasting of the smallholder farmers in their decision-making over land uses (Kahneman and Thaler, 2006).

Motivations and drivers, the role of commercial tree growing in smallholder households livelihoods and income generating activities, and the role of smallholder tree growers in forest transition processes from individual countries are many (Ayele, 2008; Boulay et al., 2012; Emtage and Suh, 2004; Hoch et al., 2012; Kallio and Kanninen, 2013; Ling et al., 2016; Martín, 2012; Meijer et al., 2015; Meyfroidt and Lambin, 2008; Oduro et al., 2018). Also, various important factors in the operational environment that enables smallholder tree growing have been identified (see Section *0 2.2*. Enabling factors below for further details) but a systematic analysis with a global perspective is lacking. Land and tree tenure security is reported to be a prerequisite for any forest management or tree growing activity (Byron, 2001; Lemenih and Kassa, 2014; Nawir et al., 2007) but the mutual relations and weight of different factors in creating favourable conditions for smallholder tree growing are mainly analysed through case-studies and qualitative analysis. Some qualitative analysis on the enabling environment for smallholder tree growing comparing countries has been done over the years (de Jong et al., 2016; Sandewall et al., 2015; Snelder and Lasco, 2008), although tree growing incentives and their effectiveness have not been analysed and compared between countries purely from the smallholder perspective, but rather as a segment of overall forest plantation development, or as single case studies.

1.5. Aim of the study

This study aims to build understanding on how smallholder land owners in the Global South respond to the changes in the enabling environment for tree growing, and identify different pathways to expand smallholder commercial tree growing area. The study also aims to build understanding of the enabling factors' significance in the early and more advanced stages of smallholder forest plantation sector expansion (see Figure 1). The focus of the study was limited to tree growing for timber and the motivations, drivers and enablers of smallholder tree growing (tree growing primarily for other purposes such as biodiversity protection or watershed management may be different compared livelihood interests.). Drivers and enabling factors discuss the same issues from different views: 'driver' is the smallholder farmers' interpretation of their socioeconomic environment motivating their tree growing, whereas 'enabling factors' link the drivers to institutions and political and market mechanisms behind the drivers.

Enters et al. (2003) suggest that different enabling factors are needed and most effective in different stages of smallholder tree growing area expansion and stabilization (see Figure 1). This study includes countries that are at different phases of their smallholder tree plantation sector development: Tanzania, Lao PDR and Uganda are at an early phase called 'initiation phase', while Vietnam and Indonesia are either at 'acceleration phase' or in transition to 'maturation phase'.

The specific objectives of this study were to:

- Build understanding of the drivers of smallholder tree growing in the Global South.
- Identify the critical enabling factors of the relatively rapid smallholder tree growing area increase, which is seemingly based on high market demand.
- Build understanding on how smallholder tree growers' access and integrate into the existing and/or emerging wood markets, and what is their role in wood supply chains.
- Analyse how tree growing incentives have functioned in varying socioeconomic and legislative environments and assess their contribution and effectiveness in increasing smallholder tree growing area.
- Identify critical factors that may either inhibit or allow expansion of smallholder tree growing area in the Global South.
- Analyse why forest policies promoting smallholder tree growing do not necessarily produce the expected outcomes, i.e. increased smallholder tree growing area.
- Identify the culmination points and the status of enabling factors in these points in the case-study countries on their smallholder tree growing pathways.

The hypothesis in this study was that smallholder tree growing may be triggered by driving forces that are not necessarily the same in different countries. Continuity of tree growing activity and further expansion of smallholder tree growing area requires the contribution of several enabling factors, while the interactions, importance and effectiveness of the factors are context-dependent.

The study draws lessons from the past but also assesses smallholder tree growers' future perspectives and interest in engaging in tree growing as a livelihood and land use option in the future. To facilitate comparisons the study

covers five countries: Indonesia, Lao PDR, Tanzania, Uganda and Vietnam through two in-depth case studies and a comparative analysis. Three papers contribute to the study. The first one is focused on Tanzania and especially the wood markets. The second paper analyses the Lao PDR and particularly the policy, legislation and incentive framework from smallholder tree growers' perspective. In Tanzania the government has intervened very little to smallholder tree growing, thus the focus of the first paper is in the market's role, whereas in Lao PDR smallholder tree growing has been promoted and heavily regulated by the government, and therefore the study assesses particularly the government's role in smallholder tree growing area expansion. The third paper aims to identify necessary factors in the political, legal, social, and market environment that enable sustained smallholder tree growing, by comparing five countries between 1990-2015 (Indonesia, Lao PDR, Tanzania, Uganda, and Vietnam) and the evolution of the enabling environment in them.

The first paper emphasises smallholders' interaction with and integration into wood markets, and wood market's role as an enabling factor, the second paper emphasises the political environment and role of incentives in creating enabling environment for smallholder tree growing, and the third paper presents a wider comparative analysis of five countries and the development of smallholder tree growing against the changing enabling environment. The first and the second papers also contribute case-studies for the third paper.

The specific hypothesis for each of the papers are as follows:

Paper I – Mapping the future market potential of timber from small-scale tree farmers: perspectives from the Southern Highlands in Tanzania.

The objective of the paper is to provide an improved knowledge related to smallholder tree growing, by focusing on pine plantations (*Pinus patula*), and on farmers' interaction with and access to timber markets and the role of markets in relation to other enabling factors in driving the expansion of smallholder commercial tree growing area.

Hypothesis: Despite the rapid increase in tree growing area driven by high market demand, in the absence of other enabling factors smallholder tree growers in the Tanzanian Southern Highlands face challenges in accessing tree growing inputs, which limits their capacity to produce high quality wood and access to wood markets.

Paper II – By accident or by design? Influence of government policies on drivers and barriers of smallholder teak growing in Lao PDR.

The objective of the paper is to examine the development of smallholder tree growing in Lao PDR against the policy, legal, socioeconomic and market background, and to analyse to what extent tree growing is induced by supportive government policies that were formulated to establish an enabling environment for smallholder tree growing.

Hypothesis: Smallholders' interest in commercial teak growing is limited due to weaknesses in the enabling environment, namely poorly designed forest policies, complexities in the regulatory environment, weak incentives, and competing land uses.

Paper III – What drives smallholder tree growing? Enabling conditions in a changing policy environment.

The objective is to identify contextual and sectoral factors and their combinations that allow smallholder tree growing to emerge in the case-study countries, which are Indonesia, Lao PDR, Tanzania, Uganda and Vietnam.

Hypothesis: Sustained smallholder tree growing schemes can emerge with varying configurations; i.e. combinations of enabling factors as drivers for tree growing. Tree growing incentives are only effective if they target and alleviate/solve the key bottlenecks or missing factors in the enabling environment.

Case studies from Tanzania and Lao PDR frame and assess the development of the forest plantation sectors in these countries and the evolution of the enabling environment for smallholder tree growing covering political, legal, and market environment, and forest sector internal factors such as wood markets, know-how, and direct and indirect incentives established to promote tree growing. Case studies analyse how the interviewed tree growers and non-growers are responding to the enabling environment, and what are their prospects for tree growing in the future thus analysing the tree growing from both from the angle of drivers and enabling factors.

The third paper analyses the role of different enabling factors through Qualitative Comparative Analysis (QCA) and discusses the role of incentives and policies in promoting tree growing. Five countries are included in the QCA (Indonesia, Lao PDR, Tanzania, Uganda and Vietnam), and each country/region constitutes several cases over time, thus altogether there are 36 cases in the analysis. Findings from in-depth studies from Tanzania and Lao PDR contribute to the enabling environment analysis in the third paper as well.

The contribution of different papers to the objectives of the study is illustrated in Figure 1 below.

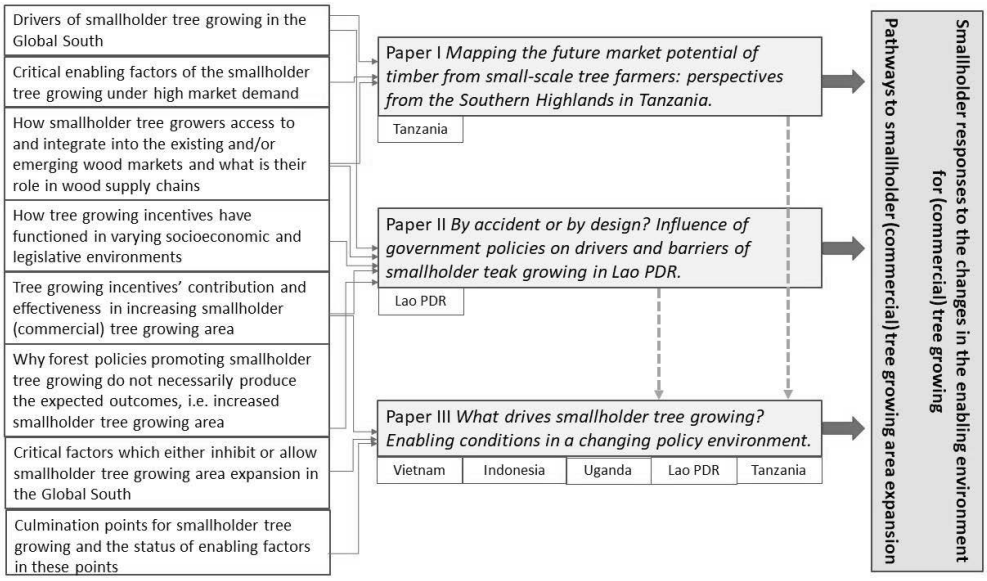

Figure 1. Research framework of the study

1.5.1. Specific research questions

Byron (2001), for example, assumes that the presence of all the previously mentioned critical factors is required for sustainable smallholder tree growing, whereas Enters et al. (2003) give a different weight for different enabling factors, including incentives, in the three stages of plantation sector development (Figure 2) based on the research findings in Asia-Pacific region.

The three papers included in this study assess the enabling environment described in this chapter to answer the specific research questions as follows:

Paper I - Mapping the future market potential of timber from small-scale tree farmers: perspectives from the Southern Highlands in Tanzania.

1) How do farmers in the Southern Highlands of Tanzania address and tackle the common problems of a smallholder tree grower such as accessing planting materials and technical and market knowledge?
2) How successful are farmers in the Southern Highlands of Tanzania in producing high quality wood?

3) How do farmers in the Southern Highlands of Tanzania access the markets, and what are the prices paid for a smallholder tree grower versus the prices paid for timber from industrial plantations?

Paper II – By accident or by design? Influence of government policies on drivers and barriers of smallholder teak growing in Lao PDR

4) How has the political and legal environment recognized and supported smallholder teak growing over the years in Lao PDR?
5) How have smallholder teak growers responded to the changes in the enabling environment for tree growing?

Paper III – What drives smallholder tree growing? Enabling conditions in a changing policy environment.

6) What are the necessary and/or sufficient conditions for sustained smallholder tree growing in the case-study countries?
7) What is the role and success of incentives in promoting smallholder tree growing in varying enabling contexts?

The methods applied in each paper are described in Chapter 0.

2. Theoretical framework

2.1. Policies promoting smallholder tree growing

Definitions of smallholder tree growing and plantations vary and are also country specific (Harrison and Herbohn, 2002). In this study 'smallholder tree growers' refers to households that own at least one woodlot larger than 0.1 ha, with their total tree growing area being less than 20 ha. The focus in this study is in commercial tree growing for wood production, thus rubber and permanent agroforestry systems are, for example, not included.

There are several economic and environmental implications of a forest transition that includes more tree plantations, as i) large-scale tree plantations tend to have limited economic opportunities for local populations, ii) they tend to mainly benefit population segments which are better off, and iii) the ecosystem services that plantations provide are poorer than in natural forests (Kröger, 2014; Malkamäki et al., 2018). However, the growing focus on smallholders' participation in tree plantations is acknowledged in a variety of political agendas (Hyde, 2019; Liu et al., 2017; Raghavan and Shrimali, 2015). In the early 1990's China, Vietnam, and Lao PDR introduced their smallholder plantation promotion policies and programmes as a part, or even as a key

element of reforestation campaigns (Cochard et al., 2017; Meyfroidt and Lambin, 2008; Pasicolan et al., 1997; Sandewall et al., 2015, 2010a; Singh et al., 2017). Indonesia has also introduced a multitude of tree growing schemes from industrial plantations to forest rehabilitation targeting communities and smallholders (Kartodihardjo et al., 2013; Maryudi et al., 2017; Ani Adiwinata Nawir et al., 2007). In Eastern Africa, including Uganda and Tanzania, such schemes were first introduced in the 2000's, often with the support of development cooperation funding and with varying combinations of direct and indirect incentives (Ainembabazi and Angelsen, 2014; Pedersen, 2017). A core element in many of the policies targeting smallholders, especially in Asia, has been land allocation, which has provided smallholders formal access to government owned lands, for example in the context of programmes aiming to eradicate shifting cultivation. Land allocation has been completed with different combinations of other direct or indirect incentives such as free or subsidized seedlings, credits, advisory and/or training services. In China and Vietnam the strongly promoted and implemented smallholder tree growing policies have even enabled a government led, smallholder-driven forest transition (Liu et al., 2017; Mather, 2007; Rudel, 2009). However, not all promotional policies and incentives have resulted in the establishment of enduring forest plantation sectors involving smallholders and maintaining viable forest industries and/or environmental services (Enters et al., 2006; Obidzinski and Dermawan, 2010), indicating that the enabling environment in which they have been implemented has not supported tree growing in the long run. The following section introduces the identification process of the enabling factors.

2.2. Enabling factors

This study aims to identify necessary and sufficient factors contributing to sustained commercial smallholder tree growing. 'Sustained' refers to tree growing which continues over rotations and after the *initiation stage* expands to new areas at national or regional levels to reach the so-called *acceleration stage*, thus becoming a significant source of wood for domestic and/or export markets. Finally, in the '*maturation stage*' smallholder tree growing becomes less dependent on external support and facilitation (such as direct incentives), and the role for public sector shifts to improving and maintaining a favourable operating environment

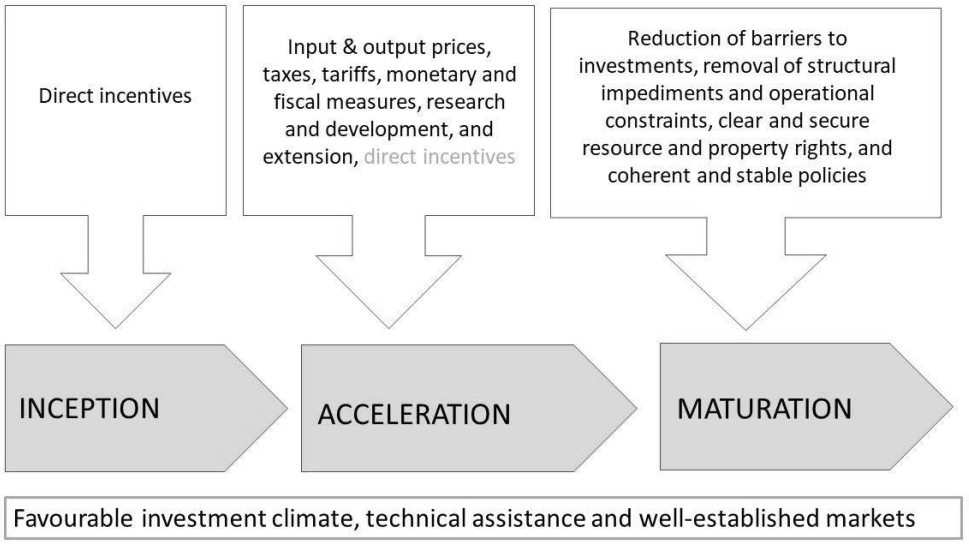

Figure 2. Enabling factors in the forest plantation sector evolution as described by Enters et. al (2003)

From the smallholder perspective tree growing is a long-term investment, even with short rotation species, thus making it in many cases a riskier land investment compared to short-term agricultural crops. Byron (2001) identified universal conditions for farm tree growing, all of which need to be present for successful sustainable tree farming:

- secure property rights to land and tree crops;
- a viable production technology (knowledge, fertilizer, credit, germplasm, etc.);
- capacity for crop protection (against fires; insects, pests and diseases, theft, and even expropriation); and
- adequate markets with attractive prices, and smallholders need to have access to these markets (access to participate and physical access)

Regardless of the country context, smallholder tree growers generally have limited availability and access to resources such as land, labour, capital and often also knowledge. Limited resources require careful consideration of feasible and secure livelihood opportunities. A similar list of premises for smallholder tree growing is formulated in the study by Sandewall et al. (2015). Pattanayak et al. (2003) found in their meta-analysis that farmer preferences,

resource endowments, market incentives, bio-physical factors, and risk and uncertainty influence their adoption of agroforestry systems.

The literature builds a very coherent picture of the enabling factors for smallholder tree growing. Based on the above and other studies of the topic (Boulay et al., 2012; Call et al., 2017a; Gebreegziabher et al., 2010; Le et al., 2012; Meijer et al., 2015), enabling or hindering factors for smallholder tree growing include demand and supply, trade, existence of open and functioning wood markets, land use competition, secure land and tree tenure, and the tradition and acceptance of tree growing among land owners and in the society in general (Bauhus et al., 2010; Bebbington, 1999; Byron, 2001; Ewers, 2006; Le et al., 2012; Macqueen et al., 2014; McDermott et al., 2009; Rahman et al., 2017). For long term sustained tree growing, political and macro-economic stability, removal of structural barriers and market distortions, and the creation of a favourable environment for enterprises are suggested to be the most effective and economically efficient incentives (Cossalter and Pye-Smith, 2003; Enters et al., 2006).

Smallholder tree growing motivations may be economic, environmental, social or cultural, or a combination of these (Evans, 2009). In many countries tree growing and tree plantations have become a 'savings account' for smallholders from which funds can be drawn (through timber sales) for larger expenditures or investments such as children's education, house construction or unexpected costs like sudden illness (Kallio and Kanninen, 2013; Snelder and Lasco, 2008).

Eight important factors for smallholder tree growing have been identified and form the basis of the theoretical framework used in this study, as presented in Figure 3.

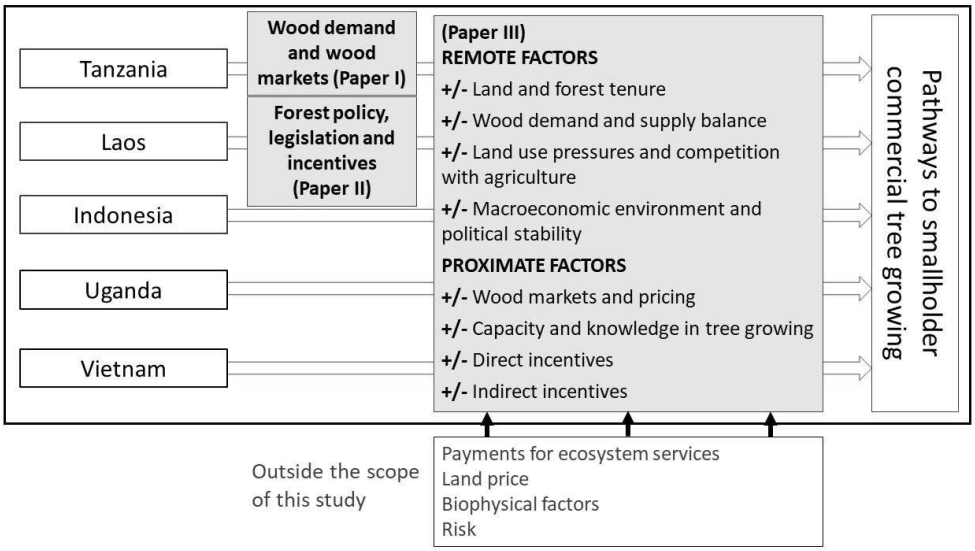

Figure 3. Enabling environment for smallholder commercial tree growing – the theoretical framework of the study

Biophysical factors were considered in the selection of the case-study countries and regions to narrow down the assessment framework by excluding arid and semi-arid regions. The first and second papers from Tanzania and Laos cover a limited geographical area where biophysical factors are very similar. In the third paper where the comparative analysis is done between countries, an assessment of biophysical factors would necessarily mean more limited geographical scope instead of the national level to allow generalizations. Climate change and its impacts on smallholder land uses and tree growing should also be considered under the biophysical environment but there is not yet enough information on the multiplicity of these impacts and how they affect smallholder agriculture and forestry in the study countries to allow categorization and comparisons. Therefore, this factor was not included in the framework directly, however it is reflected indirectly to some extent in the indicators constituting the factors i.e. indicator for agricultural productivity (Appendix 3 - Enabling factors and related indicators)

Data on perceived and experienced risks in tree growing from the smallholder perspective was collected in the field work for case studies in Tanzania and Laos, and are discussed in the context of these papers. However, data on risk was not available and not possible to collect in Indonesia, Uganda and

Vietnam, and therefore risk was excluded from the comparative analysis framework. Instead, the factor 'macroeconomic and political environment' was included to reflect higher level predictability of the operating environment for smallholder farmers.

The factors are divided into 'remote' (i.e. contextual factors) and 'proximate' factors (i.e. sectoral), and division is explained in more detail in Section 0. However, drawing the line between different factors is a simplification of the real world, since the factors are interlinked and even partly overlapping. The first and second paper of this study analyse the factors and their presence and contribution in an individual country context. The third paper pulls together the findings from these papers with additional three country cases for a comparative analysis. The factors, their indicators and justification for their inclusion is presented and discussed in more detail in the following sections.

2.2.1. Proximate enabling factors

Markets for smallholder grown wood

Wood markets are an essential element of the enabling environment linking the demand and supply (Snelder and Lasco, 2008). Smallholder tree growers commonly rely on middlemen in accessing markets, but they generally have asymmetry or lack of information on markets, thus their negotiation power is weak in the absence of alternative market options (Bienabe et al., 2004; Kaboggoza, 2011; Kallio and Kanninen, 2013; Ling et al., 2018; Mutabazi et al., 2013; Sandewall et al., 2010b). Smallholder tree growers often struggle to produce wood that meets industrial quality requirements (Nguyen et al., 2018; Phi et al., 2004) and the volumes they produce are small from the industry perspective. As a result, their produce is often sold at lower value in local markets instead of higher value addition markets in industrial chains, or used for lower value products such as chips for pulp. Failure in meeting industrial quality standards is not only caused by deficient technical knowledge, management skills, and smallholder preference for shorter-term investments, but it also signals market failure: tree growers do not have access to market information and/or market prices do not reward tree growers for improved practices and wood quality. In developing countries the challenge in implementing forest certification schemes for smallholder tree plantations is an example of this – improved practices and certification label do not provide a price premium that would compensate for the efforts and additional costs (Ling et al., 2018; Midgley et al., 2017; Nguyen et al., 2018; Obidzinski et al., 2014).

Capacity and knowledge in tree growing

Byron (2001) identified improved technical knowledge as one of the factors that reduces the perceived costs of growing trees, along with availability of technologies, extension services, capital and finance, and the same factors are listed in many studies with a varying weight of importance depending on the country context (see for example Do and Mulia, 2018; Rahman et al., 2017; Versteeg et al., 2017). Organizations producing and disseminating tree growing knowledge relevant for smallholders include research and educational institutes, extension services and farmer and tree growers' organizations. Farmer organizations are elementary in facilitating smallholders access to markets and knowledge but presently they are mainly organized around agriculture (Bienabe et al., 2004). The knowledge base can be considered supportive for smallholder tree growing if a country has some tree growing tradition and attitudes towards tree growing are positive in general. Furthermore, to provide a supportive environment, educational systems provide forest education and extension systems and/or organizations for smallholder tree growing. Tree growing technologies (e.g. improved seedlings) are available for smallholder tree growers, and optimally they also have access to additional financing for tree growing business.

Tree growing incentives

Incentives are (policy) instruments that increase the comparative advantage of forest plantations and thus stimulate investments in plantation establishment and management. Justification of incentives are often questioned, as summarized by Enters et al. (2004), "*incentives from the public to the private sector are justified, in an economic sense, when one or both of the following conditions exist: a) Social (or economic) benefits are greater than private (or financial) benefits associated with a given private action; and b) Social costs are less than private costs associated with the given action and social benefits are at least equal to private benefits".* However, specific economic analyses of the cost-benefits of past and present incentive schemes are not available in the developing country context. The purpose of incentives is to alter the land use pattern in a socially more desirable direction. According to previous research (Enters et al., 2004; Haltia and Keipi, 1997), incentives/subsidies cannot substitute other enabling factors such as proper policies and institutional frameworks.

Direct incentives are provided directly by governments, development agencies, non-governmental organizations or the private sector. They include goods and materials (for example, seedlings, fertilizers etc.); specific provision

of local infrastructure; grants; tax relief or concessions; differential fees and access to resources; subsidized loans; cost-sharing arrangements and price guarantees, and payments for ecosystem services (PES).

Enters et al. (2004) divide **indirect incentives** into variable and enabling incentives. "*Variable incentives are economic factors that affect the net returns that producers earn from plantation activities. Enabling incentives on the other hand mediate an investor's potential response to variable incentives and help to determine land use and management. They can also be viewed as elements in the investment environment that affect decision-making behaviour".* Indirect incentives for smallholder tree growing in developing countries include extension and support services, land tenure and tax benefits targeted for smallholder tree growers, local and regional infrastructure, and regulatory framework revisions to better support smallholder tree growing.

Effectiveness of different incentives changes over time as countries progress from different stages of tree growing development to the next. In the early stages of development, direct incentives are often applied, for example in the form of free seedlings, grants for tree plantation management activities, or subsidized credits. At later stages of forest plantation sector development, i.e. acceleration and maturation stages, the significance of other, mostly indirect incentives outstrips the direct incentives (Haltia and Keipi, 1997; Le et al., 2012).

Governments have played an important facilitating role in countries having a significant plantation forestry sector today, and incentives have been and still are being applied in these countries (Barua and Lehtonen, 2012; Bull et al., 2006a; Haltia and Keipi, 1997). In the 1960-1970's, many incentive schemes targeted 'private forest investments' benefitting more large-scale investors, and investments in supporting and promoting smallholder tree growers have gradually seen the light since 1990's (Rudel et al., 2016).

2.2.2. Remote enabling factors

Land tenure

Tenure rights are considered positive and supportive for tree growing if either a formal land and tree tenure system is in place and enforced, and/or landowners consider customary land ownership or local land tenure arrangements solid and reliable. If any land use planning and allocation mechanisms are in place, it should respect (customary) land tenure and allow tree growing (Chigbu et al., 2017). An indication of a secure land tenure system

is that land owners do not consider land grabbing as a major concern, there are no recent reports on major land grabbing, and legislation may also regulate the maximum size of a land holding and/or land investments may be restricted to exclude foreign entities, for example.

Demand and supply

Demand for plantation grown wood may increase if the remaining natural forests cannot meet the demand for wood, due to increasing consumption related to population growth and/or economic growth, or demand from wood industries and/or wood exports. Demand may be domestic if a wood supply deficit creates a market and livelihood opportunity for smallholders (e.g. for construction or firewood).

Land use competition

Agriculture is the main land use competitor with forestry and tree growing (D'Annunzio et al., 2015). However, agricultural intensification and urbanization together are considered key factors in the forest transition process (Youn et al., 2017).In many developing countries, especially in Africa, increasing food demand for a rapidly growing population is to a large extent met with agricultural expansion (Block, 2010; Fuglie and Rada, 2013; Pretty et al., 2011), and globally, agricultural expansion is driven by the growing demand for cash crops and animal production (Moran et al., 2015).

The amount of degraded agricultural land is increasing (Gibbs and Salmon, 2015) and attempts are being made to bring these lands back to productive use through afforestation or reforestation (Adams et al., 2016; Meyfroidt and Lambin, 2008). However, classification of land areas as under-utilized and/or degraded is also a political matter, and motives for this classification can be questioned because such classifications have been used to justify, for example, large concession agreements for foreign investors (Chan, 2016; Siscawati et al., 2017).

Agricultural policies may alter the relative advantage of different land uses and crops. Especially in the past, land policies encouraged land clearing because only agriculture was classified as a productive land use which gave the smallholder formal rights to land (Rudel and Hernandez, 2017; Simmons et al., 2018). Agriculture is commonly subsidized in many ways, for example with cheap loans, free seedlings, or fertilizers, although efficiency of these subsidizes can be questioned (Mogues et al., 2015). However, increasing awareness of forests' and trees' role in providing environmental services is likely increasing the inclusion and promotion of tree growing in the

agricultural policies (Catacutan et al., 2017; Petrokofsky et al., 2017; van Noordwijk et al., 2018).

Macroeconomic environment

Political instability has a clear and significant negative effect on economic growth (Jong-A-Pin, 2009). Although several factors contribute to the forest transition process, economic development and 'economic development pathways' together with state forest policy pathways have led to an increase in forest cover in several Asian countries in the last decades (Barbier et al., 2017; de Jong, 2010; Liu et al., 2017; Youn et al., 2017)**,** and smallholder tree growers have had a remarkable role in this change (de Jong, 2010; Lambin and Meyfroidt, 2010; Martín, 2012).

3. Methods

This is a mixed-methods study with a small number of cases, and it applies both qualitative and quantitative methods in the analysis. An in-depth analysis of the country context and smallholder tree grower and non-tree grower views requires profound insight of the country. However, the total number of countries is too small to allow drawing bold global generalizations of the findings. Specific case-studies were prepared for Tanzania and Laos, including fieldwork, whereas for Indonesia, Uganda, and Vietnam the matrixes used for the comparative analysis were developed based on a desk-study.

3.1. Study countries and data set

The author conducted field research in two of the case-study countries, Tanzania and Lao PDR, in May and October-November 2015. Field research areas in Tanzania and Lao PDR were chosen based on the popularity of tree growing in the countries. In Tanzania, the Southern Highlands area and Njombe region are known to be experiencing smallholder tree growing booms. In Lao PDR, Luang Prabang Province has a long tradition of teak growing, and in Vientiane Province tree growing has emerged due to growing wood demand in the capital area and with the support of some tree growing promotion projects in the past.

Villages were selected in collaboration with research partners to represent different combinations of distance to markets and availability of extension services, see Table 1.

Table 1. Village classification for village selection and analysis according to wood market proximity and availability of extension services in the village

Village characteristics	**Close to main roads/markets**		**Far from main roads/markets**	
	Tanzania	**Laos**	**Tanzania**	**Laos**
Receiving extension	Iboya	Ban Xiengloum, Luang Prabang Province	Matembwe	Ban Ensavanh, Luang Prabang Province
Number of Interviewees	Tree growers: 15 Non-growers: 4	Tree growers: 15 Non-growers: 16	Tree growers: 15 Non-growers: 8	Tree growers: 16 Non-growers: 9
Not receiving extension	Itipula	Phialat, Vientiane Province	Utilili	Ban Thinsom, Luang Prabang Province
Number of Interviewees	Tree growers: 15 Non-growers: 9	Tree growers: 15 Non-growers: 15	Tree growers: 15 Non-growers: 15	Tree growers: 16 Non-growers: 15

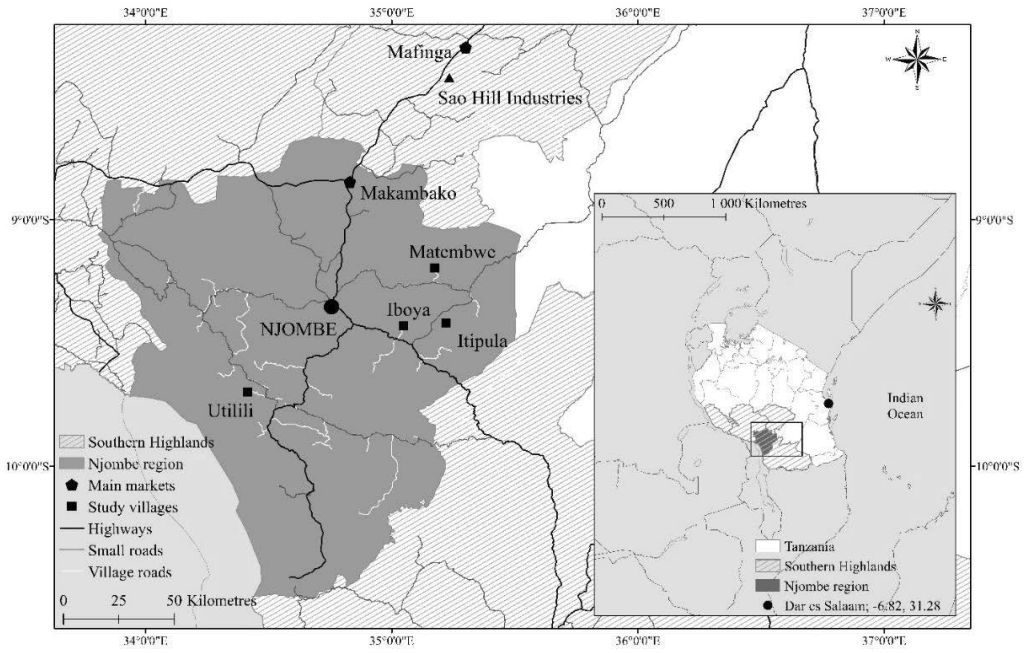

Figure 4. Map of the study area and villages in the Southern Highlands of Tanzania

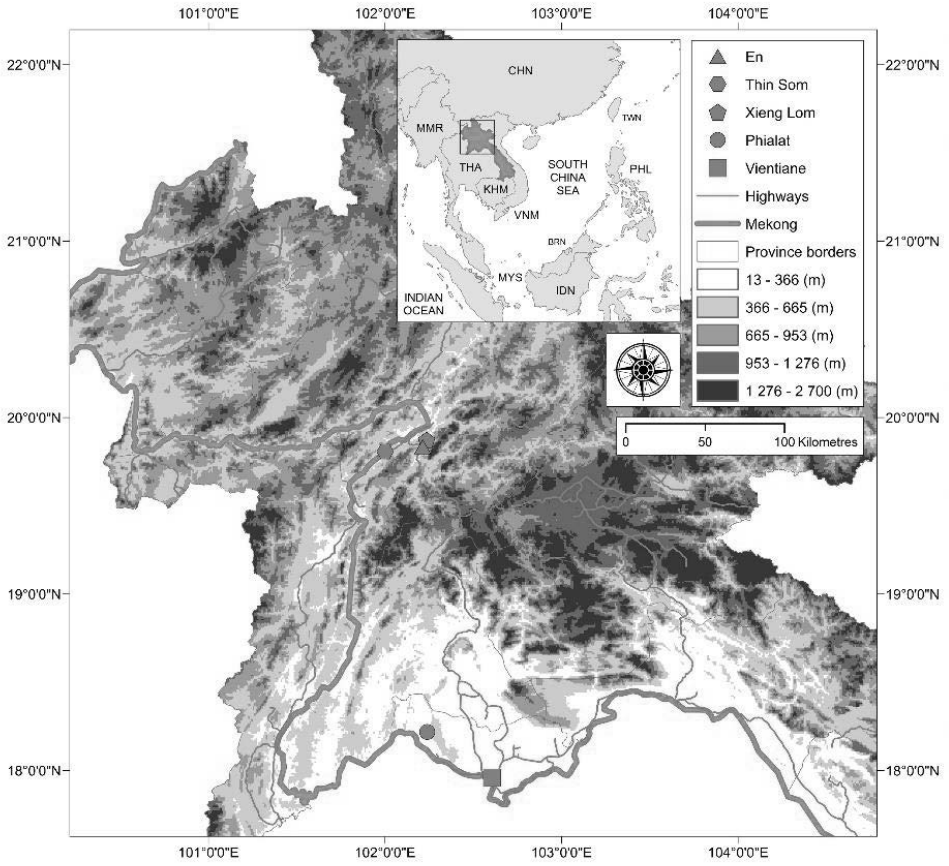

Figure 5. Map of the study area and villages in the Lao PDR

3.1.1. Sampling of respondents

In each village 15 'tree growers' and 15 'non-growers' were randomly selected from a list formulated by the village head, with ranking of households into three socioeconomic sub-groups: high, middle and low-income households (five 'tree grower' and five 'non-grower' households per socioeconomic sub-group). The listing was supported by the village household records. The socioeconomic ranking was subjective, but on the other hand also reflects the perception of living standards in the region and in the village. Some adjustments were made to exclude households having a close family relationship. Socioeconomic sub-grouping was only used to diversify the

sample of interviewees, not in the data analysis. There were no tree growers in the low-income household group in one village in Tanzania (Matembwe) thus ten households were selected from the middle-income sub-group.

The case-studies and the interviews cover only resident tree growers, although in Lao PDR the share of absentee land owners may be significant (Ling et al., 2018; Newby et al., 2012). However, reaching these absentee landowners for an interview was complicated (contacting, scheduling interviewees, and travel) and they were excluded from the study simply for practical reasons (time and budget constraints). In Tanzania trees were mainly grown by resident villagers and smallholders, or occasionally by external investors on village reserve lands that the village had either leased or sold to the investors.

3.1.2. Interviews

In Tanzania tree growers were interviewed on their woodlots where basic stand measurements were also made. In Lao PDR the interviews were organized either at the respondent's home or at the village 'meeting house' with each interviewee on a one-on-one basis[1], and a separate visit to their woodlot was organized when possible. Each interviewee was asked for their willingness to participate in the research and permission to record the interview. The semi-structured interviews (Appendix 1) were carried out based on a questionnaire covering household's basic information, income sources and their importance, farming activities, detailed information on woodlots and their establishment and management, extension, drivers and challenges of tree growing, and future perspectives. In the analysis of interview data, similar answers on open ended questions were identified and categories formulated accordingly. Interviews were conducted in local language by a local extension officer (in Tanzania from a project, in Lao PDR from the government working for a tree growing extension project) with the support and presence of a research team member. In Lao PDR, the eam visited interviewees' teak plantations whenever possible (58% of the owners) to cross check and validate their answers on site quality, plantation management and condition, and to estimate basic stand-level variables using *Trestima* mobile application. In 42% of cases difficult access/remote location prohibited site visits. This causes a slight risk for the reliability of some answers (e.g. on management), but does not influence the main questions analysed in this study, as the questions on management and

[1] In Lao PDR the government has a history of controlling citizens interactions with foreigners, thus visits to private homes are not easily organized.

extension were asked to verify level of knowledge, and availability and influence of capacity building services for smallholders.

Market data on teak and pine was collected through interviews with middlemen and wood traders and processors, and in Lao PDR also from government records. Regarding the wood sales, the information is patchy in both countries and only gives a general overview because most wood sales do not follow the formal procedures for licencing, and as such these volumes and prices are mostly not recorded (Moore et al., 2016; Smith, 2014).

3.1.3. Woodlot inventories

Farmers or their representatives provided directions to his/her woodlot. In Tanzania 60 woodlots were measured with three circular plots per woodlot, taken along a straight line across the woodlot. In three woodlots, one in Iboya and two in Itipula, only two plots were measured because accessibility within woodlots was difficult due to extremely thick understorey vegetation. Woodlot areas were measured using GPS tracking round the woodlot outer limits. Distances between the plots were adjusted according to the length of the total diagonal of the woodlot (Table 2). Different radiuses were used in circular plots depending on accessibility and density of trees. The radiuses used and the corresponding multipliers to estimate units per hectare are presented in Table 3 below.

All trees within a plot were counted and their diameters at breast height were measured using a diameter measurement tape (talmeter). Tree defects were visually observed and recorded. Tree height was measured with hypsometer for trees with lowest and highest diameters, as well as for trees with diameter next to the median diameter tree (four trees in total per plot). The pruning height, and dead and living branch heights were also measured. Observations on the amount of undergrowth, signs of soil preparation, and slope gradient were also recorded in the inventory sheet. Seedling stands of diameter less than two centimeters were measured only for height. Inventory data was recorded to a field inventory sheet (Appendix 2).

Table 2. Distance between plantation inventory plots for plot sampling

Woodlot diagonal (m)	Distance between plots (m) (from: border to 1st plot – 1st to 2nd plot – 2nd to 3rd plot)
<90	10 – 20 – 20
90-120	15 – 30 – 30
120-150	20 – 40 – 40
150-180	25 – 50 – 50
180-210	30 – 60 – 60
210-240	35 – 70 – 70
240-270	40 – 80 – 80
270-300	45 – 90 – 90
>300	50 – 100 – 100

Table 3. Plantation inventory sample plot radius (m) and multipliers used for conversion of results per hectare

Radius (m)	Multiplier
5.64	100
6.51	75
7.98	50

3.1.4. Country matrixes

Country information was compiled in data matrixes organized according to enabling factors. Factors included in the enabling environment framework in this study were identified and selected through a literature review presented earlier in Section 0. Each factor consists of several indicators that are described in detail in Table 4 and Appendix 3. A preliminary long list of factors and their indicators was reviewed and reduced through an iterative process with research partners in which related factors were combined and certain indicators excluded or modified to meet the theoretical assumptions and to remove overlaps. Final modifications were made based on the fieldwork findings and on the fitness of the collected data. For example, taxation on agriculture and forestry was found to be considered as being either irrelevant for smallholders, or similar for agricultural and forestry practices, thus it was excluded as an indicator of the legislative and policy environment.

The desk review collected and analyzed an extensive amount of relevant previous research and existing documentation, which were searched by

country using Google Scholar, Web of Science, and Google. Specific key words for each factor were derived from the indicator description. Document relevance was assessed on the abstracts or summaries of the documents, and on the presumptive reliability of the source, as all the documents were not from peer-reviewed journals. Only established, reputable institutions (such as government institutions, civil society organizations and reputable private sector actors such as consultancy companies) were considered as a reliable source.

Field research findings from Tanzania and Lao PDR were combined with the data collected in the literature review. A major part of the data collection for Vietnam, and partly for Indonesia, was carried out by research partners from the Center for International Forestry Research (CIFOR). Country experts with in-depth knowledge of the issue reviewed all the country matrices to validate the data and its interpretation in the matrixes.

Analysis of the Indonesia data showed significant differences in the enabling factors between Java, Kalimantan and Sumatra. Summarizing the data and using averages would not establish a realistic picture of any of the islands, therefore the islands are presented as two regions and separate cases in the analysis Java being one case and Kalimantan and Sumatra combined as another case.

Table 4. Enabling factors for smallholder commercial tree growing

Contextual (Remote) factors	**Abbreviation**	**Present (supportive for commercial tree growing) if:**
Land and tree tenure	**TEN**	Land ownership is strong and respects individual tree growers' rights and allows for tree growing.
Demand and supply balance	**DEMSUP**	Strong domestic or/and export-oriented wood demand.
Agricultural pressure	**AGR**	Agricultural policy does not incentivize for land conversion to agriculture at the cost of forest/plantation, and/or incentivizes tree growing/forest management to provide environmental services for agriculture. Demographic patterns and agricultural technology development are decreasing the pressure for more agricultural land.
Macroeconomic development and political stability	**MACRO**	The country is either at least a lower middle-income country and/or annual GDP growth has been >5% for the past 10 years. Political stability ranking (using World Bank data) is ≥0 (scaling from -1 to +1).
Sectoral (Proximate) factors	**Abbreviation**	**Present (supportive for commercial tree growing) if:**
Wood markets and pricing	**MAR**	Wood pricing is market based (not regulated) and smallholders have access to wood markets through a reasonably well working market mechanism.
Capacity and knowledge	**KNOW**	Smallholder tree growers have adequate tree growing knowledge, and/or access to financing and good quality extension services for tree growing.
Direct incentives	**DIRINC**	Forest policy is in place, and direct incentives are applied (seedling, grants etc. to tree growers, extension services, allocation of land for tree growing),

		and they significantly increase the attractiveness of tree growing for smallholders vs. other land uses.
Indirect incentives	**INDIRINC**	Forest policy is in place and identifies the indirect incentives, and they are applied (e.g. removal of bureaucratic barriers, research, market development, land tenure-related benefits etc.). Indirect incentives have significantly improved the operating environment for tree growing (e.g. services and training for tree growers, market development, etc.). Regulation and bureaucracy of smallholder tree growing is at a reasonable level and its costs are modest vs. the expected profits from tree growing. If fees and licenses exist, but are not applied in reality, the regulative environment can also be considered supportive for smallholder tree growing.

3.2. Analysis methods

3.2.1. Analysis of the country cases

The interviews were analysed, and open-ended questions categorized and coded (see coding in Appendix 1). The sample size in field interviews is small and sampling methodology contains subjective elements, thus the statistical analysis of the interviews was limited to descriptive methods and methods applicable to small samples (Mann-Whitney U-test, Spearman correlation, Chi-square). Analysis covered the relationships between socioeconomic factors and tree growing activity, and a comparison of tree growers' and non-growers' groups. In the statistical data analysis 'village' was mostly one variable included in the analysis, but comparisons were also made between the villages through cross-tabulation.

3.2.2 Qualitative Comparative Analysis (QCA)

Qualitative Comparative Analysis (QCA) is based on an assumption of complex causality and more specifically on multiple configurational causality. This means that multiple pathways might lead to the same outcome instead of

a linear additive model in terms of changes to a condition (Berg-Schlosser et al., 2012).

Multiple configurational causality is based on assumptions that a combination of different conditions, rather than a single condition, causes an outcome. The concept of conjunctural causation (or multi-finality) means that a condition may have different or even opposite effects on the outcome depending on the context. Equifinality means that different (combinations of) conditions can lead to the same outcome (Fischer and Maggetti, 2017). Contrary to variable-oriented methods which analyse variables' net-effects over a large number of cases, QCA aims to explain all cases as comprehensively as possible by taking into account a set of explanatory factors and their complex combinations, making it compatible for policy and policy-outcome analysis.

In this study, the nature of the research question and the quality of data available on enabling environment factors in developing countries limited the available methods for a comparative analysis. The underlying hypothesis in this study is that several factors and their combinations may lead to the outcome, i.e. increased smallholder tree growing. The development of an enabling environment is not a linear process, but the interest is rather in critical junctures or tipping-points. In addition to the identification of critical enabling factors, this study also compared the enabling environment evolution over time in the case-study countries.

The time dimension and evolution of the enabling environment is analysed by applying 'Time Differencing QCA', which is concerned with a relative change between two given time points within the same spatial unit and assigning values based on an 'increase' or a 'decrease' (Hino, 2009). The time series was created to a) assess the changes in the enabling environment over time, b) analyze the consistency of the policies supporting smallholder tree growing, and c) analyze the permanence and strength of tree growing trends and smallholder interest in tree growing. Assessment of the enabling environmental factors was conducted for each country for years 1990, 1995, 2000, 2005, 2010, and 2015.

Selection of the case-study countries and time intervals

This study is a stand-alone study with limited (human) resources, thus the possible number of case-study countries had to be kept low to allow acquiring in-depth knowledge, which is a precondition for inductive elaboration of theoretical explanations (Fischer and Maggetti, 2017). Criteria used to select the countries were:

- Emerging commercial smallholder tree growing (for timber) within the last 30 years
- Previous research on tree growing and forest policy, or other available data sources to cover the 30-year period
- Author's own knowledge on the country
- Partner availability in the countries to support data collection and review.

A relatively long time period was also necessary for the analysis of tree growing trends and whether they can be considered 'sustained'. Tree growing is a long-term investment and tree species grown in smallholder plantations take from five up to 30-years to mature, depending on the species and final use of the wood produced. Also, the macroeconomic environment develops over a relatively long time period and its influence on investment decisions and smallholder decision making becomes visible with delay (Korhonen et al., 2014; Samimi and Jenatabadi, 2014). A thirty-year time period should allow both changes in the macroeconomic environment become visible, and on the other hand, helps to avoid bias created by short-term economic shocks, for example. Five-year intervals to assess changes in factors should allow changes in policies and legislation to become visible.

Specification of the enabling factors through indicators

Each enabling factor consists of several indicators (see Supplement B in Paper III for more details). The majority of the indicators are qualitative and setting a numeric value and scale for them would be challenging, therefore they were given a binary value being either supportive (POS = 1) or hindering (NEG = 0) for smallholder tree growing. A factor is considered 'present' (i.e. supportive for tree growing) if a pre-set number of indicators are present and receive 'POS' value.

Compilation of the data matrixes

Country information (indicators) was compiled in data matrixes organized according to enabling factors. Desk review collected and analysed relevant previous research and existing documentation from all case-study countries to answer the questions related to factors and their indicators in the data matrix. In the case of Lao PDR and Tanzania, field research findings (Papers I and II) were combined with the data collected in the literature review and contributed in setting the values for indicators. Data collection for Vietnam was mainly carried out by research partners from CIFOR. All country matrixes were

reviewed by partners with in-depth knowledge of the country and the sector and they are included as co-authors of the paper.

Selection of the QCA method

The selection of the QCA method was guided by the Paper III research questions and the nature of the data. The research questions in the third paper are:

1) What are the identifiable necessary and/or sufficient conditions for sustained smallholder tree growing in the five case countries?

2) What is the role and success of incentives in promoting smallholder tree growing in varying enabling contexts?

The enabling factors identified fall naturally in two categories, as 'remote' or 'proximate' factors. An assumption in this study is that presence of some remote (contextual) factors is necessary before the proximate (sectoral) may become effective, thus the two-step QCA methodology would best serve in the analysis as described by Schneider and Wagemann (2006). Remote factors are those that are often called structural factors or the context. They remain rather stable over time, and their origin is often remote on the time (and space) dimension from the outcome. They do not directly produce the outcome but provide the context within which proximate conditions unfold their effect on the outcome (Schneider, 2018). As a result, present actors, i.e. in this study institutions working in tree growing sector and tree growers themselves, have now direct influence on the remote factors and they can be considered as 'given'. Instead, proximate factors both vary over time, are temporarily and spatially closer to the outcome, and the actors involved have an influence on them. The second research question on incentives also informed the selection of the methodology towards the two-step approach as the incentives are analysed within a framework of other, contextual enabling factors.

The number of cases in this study (36) represents limited diversity of factor combinations, and the number of factors included in the analysis (8) potentially leads to a high number of logical remainders (i.e. possible combinations of conditions/factors that are not present in the data). The total number of factors (8) would produce 256 possible configurations (combinations of factors) thus the number of logical remainders would be high. Using the two-step approach with four factors in both steps reduces the number of possible configurations to 16 in each step.

Even though fuzzy-set QCA (fsQCA) would allow more gradual assessment of the enabling environment development, with the small number of cases and eight factors it would also increase the number of logical remainders. In fsQCA setting and justifying scales for conditions/factors would also be more complicated, especially because most of the indicators are qualitative. Therefore the crisp-set approach was chosen (i.e. classifying conditions/factors as being either present [1] or absent [0]).

Software for QCA analysis

The analysis was run with *Tosmana* software (Cronqvist, 2017) and verification of the results utilised *Kirq* (Reichert and Rubinson, 2014) and *QCA 3.0* software (Dusa, 2019). The script of the verification process with QCA 3.0, is based on the script formulated by Ioana-Elena Oana (Central European University, Budapest) (available as an appendix in Paper III).

Setting the thresholds and sensitivity analysis

Absence of comprehensive, comparable and reliable statistics or maps on smallholder tree growing in the case-study countries does not allow a systematic numeric description and comparison of the outcome (smallholder tree growing area) between years and countries. Instead, estimates of smallholder tree growing areas were searched from available statistics, published studies, and other secondary sources to build understanding of tree growing trends and its strength. The scale measuring the outcome was set simply as weak-moderate-strong, and 'moderate' and 'strong' status were considered as a positive outcome receiving the value [1].

As recognized in the more recent QCA methodology development, employment of the complexity reducing logic of QCA necessitates a calibration of the data (Skaaning, 2011). In this study the sensitivity of the dichotomized model was tested by running the same model with different factor threshold values in critical tipping points. The sensitivity analysis is described in more detail in Appendix 4.

4. Results

Sections 4.1-4.3 present the findings of the study by research paper. The key results are then summarized in Section 4.4.

4.1. Smallholder commercial tree growing from the market perspective in Tanzania (Paper I)

4.1.1. The role of tree growing in smallholder livelihood strategies in the Southern Highlands of Tanzania

Both tree growers and non-growers mainly depended on subsistence agriculture based on maize and beans for their livelihoods. Out of 60 interviewed tree-grower households, 60% reported that 90–100% of the maize grown was for their own consumption only, whereas 63% of non-grower households used over 60% of the maize produced for their own household consumption. Fifty-two percent of the tree-grower households used temporary external labour on their farms (Table 5).

Income in non-grower households was smaller in general, and their family size was smaller as many non-growers were elderly people or young families (Table 5). Agriculture was the main cash income source for tree growers in Iboya, Itipula and Utilili (Table 6). During the previous year, tree growing was a significant income source in Matembwe and Itipula (53% and 40% of respondents), and 40% of interviewees in Matembwe were also involved in small businesses. Domestic animals were the second most important income source in Utilili (67% of interviewees). In the non-growers group interviewees had difficulties in separating their income from different sources thus the income was grouped into only two groups: ‘crops and animals’, and ‘business and labour’ (Table 6, Table 7). Non-growers in Iboya, Itipula and Matembwe had their income mainly from labour work and business, indicating their limited access to land (Table 7, Table 5). In Utilili non-growers had more land available and crops and animals were also their main source of cash income.).

Table 5. Key characteristics of, and differences between, tree growing and non-growing households (Conversion rate 1st of May 2015 1 USD = 1 929 TZS)

	Tree growers (N 60)				Non-growers (N 36)			
	Min	**Mean**	**Max**	**Std.d.**	**Min**	**Mean**	**Max**	**Std.d.**
Age of HH head	28	46.1	78	11.84	25	53.14	84	16.97
Family size	1	6.28	17	2.69	1	4.17	10	2.47
Income (thousand TZS)	50	1 990	10 000	2 152	0	314	1 500	413
Income/head (thousand TZS)	10	361	2 250	457	0	78	620	113
Farm land area (hectares)	0.85	7.62	43.06	6.19	0	0.79	8.09	1.61
Area planted with trees (hectares)	0.40	5.05	13.86	3.83				
Share of land planted with trees	3	64.95	96	21.64				
Share of HH with sufficient maize	92%				67%			
Share of HH with sufficient beans	68%				44%			
Share of HH with external labour	53%				19%			

Table 6. Contribution of different income sources in tree growing households' livelihoods (% of the total income) in the study villages

		Crops and animals	**Labour and business**	**Forestry**
Close to markets	Iboya	80	16	4
	Itipula	43	32	25
Far from market	Matembwe	34	34	32
	Utilili	94	6	0
Average		63	22	15

Table 7. Contribution of different income sources in non-grower households' livelihoods (% of the total income) in the study villages.

		Crops and animals	**Labour and business**
Close to markets	Iboya	3	97
	Itipula	25	75
Far from market	Matembwe	38	62
	Utilili	95	5
Average		40	60

Pine is the dominant species in smallholder woodlots in the Southern Highlands: 87% of the interviewees' woodlots were pine (*Pinus patula*) and 8% eucalyptus (*Eucalyptus* spp.). Woodlots were mainly established on former agricultural land (67%) or on open/grass land (21%). The rest was mainly on former grazing land (6%) or they were replanted tree plantations (3%). Tree plantation size has grown over time: prior to the year 2000, individual, very small woodlots were established. Since 2007, both the number of plantations established (Figure 6) and mean plot area have steadily increased.

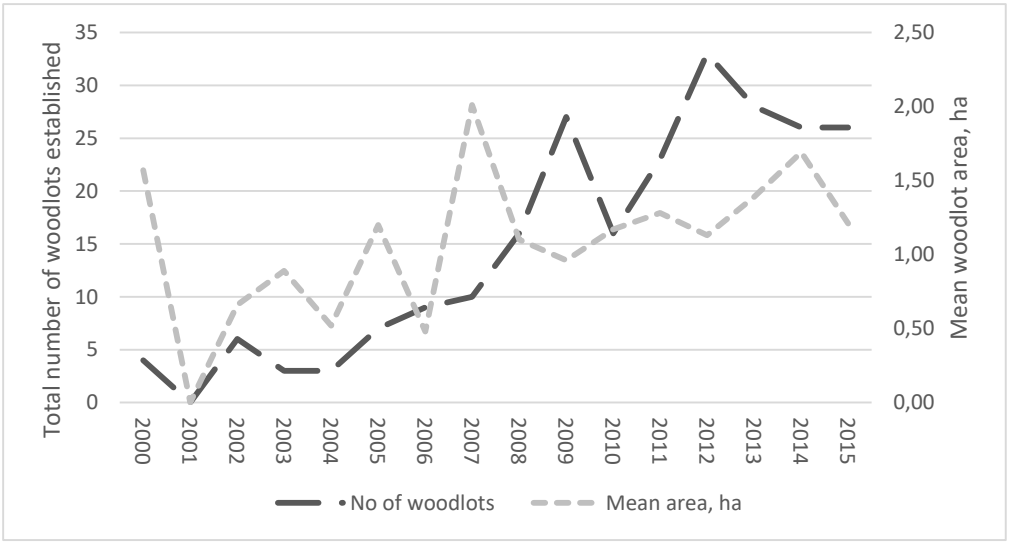

Figure 6. Number of woodlots established per year and mean area (hectares) of established woodlots among the interviewees.

4.1.2. Common challenges in tree growing

The most common problem or risk that both tree growers and non-growers (who are planning to plant trees) mentioned in tree plantation establishment and management was high fire risk, which was mentioned by 70% of the tree growers and 71% of non-growers (Table 8). In general though, non-growers expected different kinds of risks compared to tree growers. Tree growers mentioned problems including challenges in seedling transportation, poor availability of seedlings, problems in labour availability, and grasses and weeds on the woodlot, with only 17% of tree growers reporting that they have no problems in tree growing. Non-growers were concerned with risks such as lack of knowledge, excessive amount of work, long waiting period, high tree mortality, poor availability of quality seeds/seedlings, and high investment and/or management costs.

Table 8. Problems encountered or anticipated in tree growing among tree growers and non-growers planning to plant trees in the Southern Highlands

Problems	Tree growers (N=60) (encountered)	Non-growers (N=36) (anticipated)
	%	%
Resource problems		
Labour to do establishment (availability and/or skills)	12	0
Excessive amount of work	0	24
Reduced availability of agricultural land	0	5
Protection of water resources	3	0
Land grabbing	2	0
Long period before trees produce income	0	24
Inadequate information/knowledge	0	38
Establishment-related problems		
Transport of seedlings (long distances or poor road conditions)	17	
Poor quality of seeds/seedlings	8	0
Poor availability of seedlings	0	10
Not enough seedlings	17	0
Management problems	0	0
Fire	70	71
Pests/diseases	7	0
High tree mortality	0	10
Lots of grasses/weeds	13	0
Harm from grazing animals	8	0

Land tenure and land allocation for tree growing amongst tree-growers

The share of household land allocated for tree growing varied between 18–96%, with the mean share being between 69–77% in Iboya, Itipula, and Matembwe. In Utilili, which is further from the markets and where more land is still available, variation was between 3 and 86% and the mean share of land allocated for tree growing was lower (44%) compared to the other three villages (Table 9).

The only socioeconomic factor that clearly correlated with the area allocated for tree planting was total land area available (p=0.000, Figure 7), whereas

other factors such as household income, for example, had no significant correlation with plantation area. Tree growing area per household increased mainly through an increase in woodlot size, and less so through increasing number of woodlots.

Land tenure is organized under the village land system, but none of the interviewees had a formal land title for their woodlots validated under the national land registration systems. Despite this, only a few mentioned any problems or conflicts in land ownership. External investors' interest in village lands is reported to be high and, for example, Iboya Village had sold some village lands to an external investor for tree growing.

Table 9. Land area available (ha) and share of land allocated for tree growing by village among tree-growing households

(n =15 in all the villages)	**Close to markets**		**Far from markets**	
	Iboya	Itipula	Matembwe	Utilili
Average farm area, tree growers (ha)	8.7	7.2	8.8	8.8
Average tree growing area (ha)	7.1	5.3	5.4	2.6
Average farm area, non-tree growers (ha)	0.3	1.5	1.4	2.7
Share of land planted for trees, % (range of variation in parenthesis)	77 (33-86)	69 (18-96)	70 (48-91)	44 (3-86)

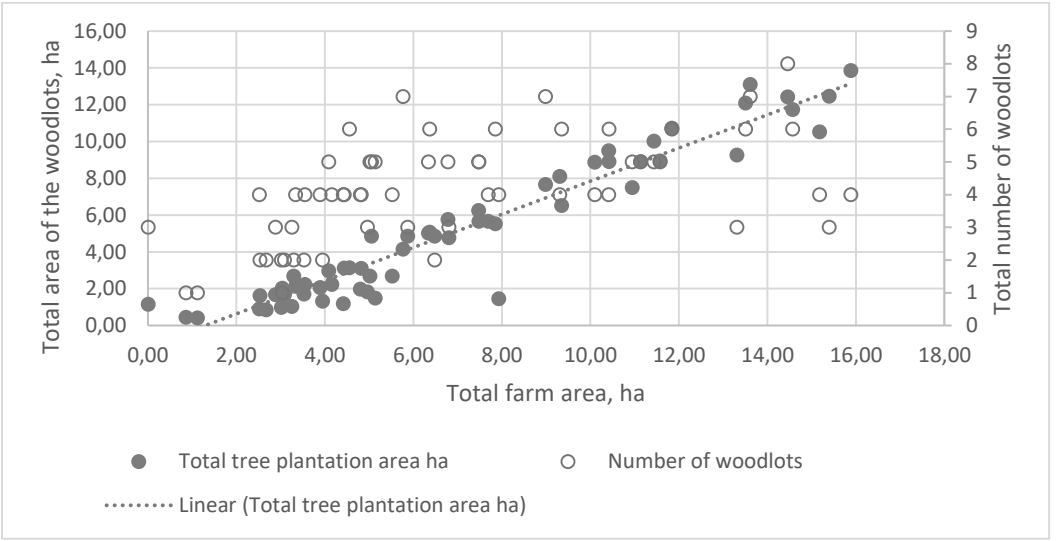

Figure 7. Share of land allocated for tree growing and number of woodlots among tree-growing households

All the tree growers had established their woodlots primarily to produce timber for sale, and 43% said that commercial timber production is their only motivation for tree growing, with the rest (57%) saying they also value the secondary products (i.e. firewood and construction wood for household use).

Access to planting materials, tree growing knowledge, and extension services

Smallholder tree growing relies heavily on local seeds and seedling production. The two most common methods for obtaining seedlings were collecting seeds from the woodlots in the village and growing the seedlings at home (47%), or buying the seedlings from the other villagers (28%). Almost one-third (30%) of tree growers had sourced seeds from outside the village, for example from a company planting trees in the region. Until recently, farmers did not have access to high-quality seedlings, and the available species and locally produced seedlings were limited to exotic species such as *Pinus patula*, certain *Eucalyptus* sp., *Cupressus lusitanica,* and *Acacia* species introduced in the region during the last decades. Private Forestry Programme, a development cooperation programme implemented in collaboration with the Finnish and Tanzanian governments, had distributed improved (free) seedlings in 2014 and 2015 in Iboya and Matembwe, but the resulting woodlots were not measured in this study (only woodlots with a minimum of three years old were measured). As discussed in the section *Common challenges in tree growing*

above, tree growers listed poor availability of high-quality seeds and seedlings as one of the problems, whereas non-growers mentioned access to seedlings in general as being a problem.

As mentioned in Section 4.1.1, the majority of woodlots are on former agricultural land. This is partly linked to a commonly applied '*taungya*' practice where intercropping is practiced during the first year(s) of the plantations. Some one-fourth of the interviewed tree growers had applied intercropping for the first 1–3 years of their tree plantations.

Extension services have only recently become available in Matembwe (since 2010), Iboya (2014), and to some extent in Itipula (2014) through the Private Forestry Programme. Therefore, smallholders have obtained their tree growing knowledge from their families, or other villagers. Before the launching of the programme, very few (10%) had received any extension or technical advice. Altogether, less than half (45%) of the tree growers reported having received extension support on varying topics, and mainly through the recent extension programmes. District forest office (government) advice has been received by eight farmers (13%), and a few interviewees mentioned missionaries, schools, or previous tree-planting and -growing programmes as the source of tree-growing knowledge.

Extension services that tree growers received had focused on plantation establishment, and early management and pruning were also addressed to some extent (10–12%). Very few (8%) said they had received advice on assessing timber value or on wood marketing or sales.

In the study villages knowledge and practices on tree growing have been simply copied from neighbours or relatives. Matembwe had the longest history of extension services (since 2010) and tree growers invested there the most in tree plantation establishment, but this was not visible in the quality of the measured woodlots compared to other villages. Extension services were highly appreciated in the villages where Private Forestry Programme was working, but despite increased awareness of the significance of planting material for plantation performance, interviewees' management practices had not changed much as the 'demonstration effect' of improved management practices was yet to be created (Kassie et al., 2013). For example, the improved seedlings the programme had distributed were highly valued, but tree growers had not realized that the benefits of the improved seedlings only materialize when combined with improved management practices.

Farmers' capacity to protect their tree plantations is listed as one the preconditions for tree growing investment (Byron, 2001; Sandewall et al., 2015). Fire, which 70% of tree growers and all non-growers in Tanzania considered as a significant risk, was the main concern both among the tree growers and non-growers interesting in planting trees. Despite the disincentive of the high fire risk, smallholders consider the tree growing as an attractive business and their concern and limited options in controlling forest fires, at least at an individual level, did not truly decrease the interest in growing trees. The benefits expected were high enough to justify the risk, perhaps due to the fact that losses are limited in financial terms because of the use of homegrown seedlings and household labour. This could be supported also by an emerging interest and mechanism at the village level to control fires, as tree growing has become such a widespread activity creating a common interest in fire management.

In Tanzania the government has had a laissez-faire approach in smallholder tree growing as the present forest policies, legislation, and regulations do not even recognize smallholder tree growing activities. This has allowed the smallholder sector to develop and flourish but has also left the smallholders without any supportive frameworks or services. However, considering the budgetary constraints of the Tanzanian government, resources to support smallholder tree growers would not have been available without external donor support anyway, even with a guiding policy and regulation.

4.1.3. Quality of smallholder produced wood and investment in forest management

Tree growers had invested their time and money in plantation management, and the few exceptions were mainly elderly farmers who could no longer work. Pruning was the most common activity, practiced by three out of four tree growers. However, the lack of advice and proper tools for plantation management were clearly visible in the quality of management, and particularly pruning. On recently pruned woodlots the damage (long sticks left on the stems or damage caused to the trunks) was clearly observable (Figure 8). Damage caused by earlier pruning is not necessarily observable but may be reflected in other types of stem defects. Despite the history of extension since 2010, in Matembwe all measured woodlots had visible damage caused by pruning, in Utilili 67% and Itipula 20%, but with none in Iboya. However, the low incidence of observed damage in Iboya and Itipula does not mean they would not exist; most of the woodlots measured in Iboya were more than six years old (8 and 11) and pruning damage from earlier years may not be visible

anymore. The large number of curved stem bases in the data (14% of all trees measured) is likely caused by poor planting techniques. Slightly more than half of all trees had no (47%) or only mild defects (11%), and they have the potential to produce high-quality wood for timber, while the rest will only be suitable for pulp- or firewood.

Figure 8. Damage caused by poor pruning techniques (Photos by Juho Penttilä)

Household socioeconomic factors and investment in management activities showed no significant association in the statistical analysis. Instead, interviewees' perception of the tree plantation quality influenced the amount of management practices: the better the perceived quality of the plantation, the less forest management activities were performed, as farmers were satisfied with the current condition of their plantations.

Tree growers do not apply fertilizer and they use the same tools used for agriculture, thus cash invested in tree growing was used for seedlings or hiring outside labour. Slightly more than half (53%) of the tree growers invested only their household labour during the plantation establishment phase, while 37% invested both labour and cash, and 10% invested only money. Fifty percent of farmers invested only household labour during early management, while 20% invested both labour and cash. A few (7%) invested only cash, and 24% had

not conducted any early management activities. An average investment was less than 100 000 TZS per ha for establishment and less than 50 000 for early management (< 50 USD and < 25 USD) but variation between villages was relatively large (Figure 9). Farmers considered planting home-grown tree seedlings on agricultural land with agricultural crops as a zero-cost investment.

Most interviewed tree growers allocated less than 10 days per hectare in all three management phases: establishment, early management (until the time when the first thinning should take place) and late management (time when thinnings should take place) (Figure 6). A zero-investment made during plantation establishment is explained with intercropping: when trees are planted together with agricultural crops, farmers consider no time to have been spent during the establishment phase.

To estimate the opportunity cost for the use of labour, the time (days) allocated for plantation establishment and management was converted into monetary terms using the local minimum daily salary rate of 10 000 TZS. On average, Matembwe farmers invested the most time in tree plantation establishment and the management of young stands, and their total investment in young stand management was larger compared to other villages (Figure 9).

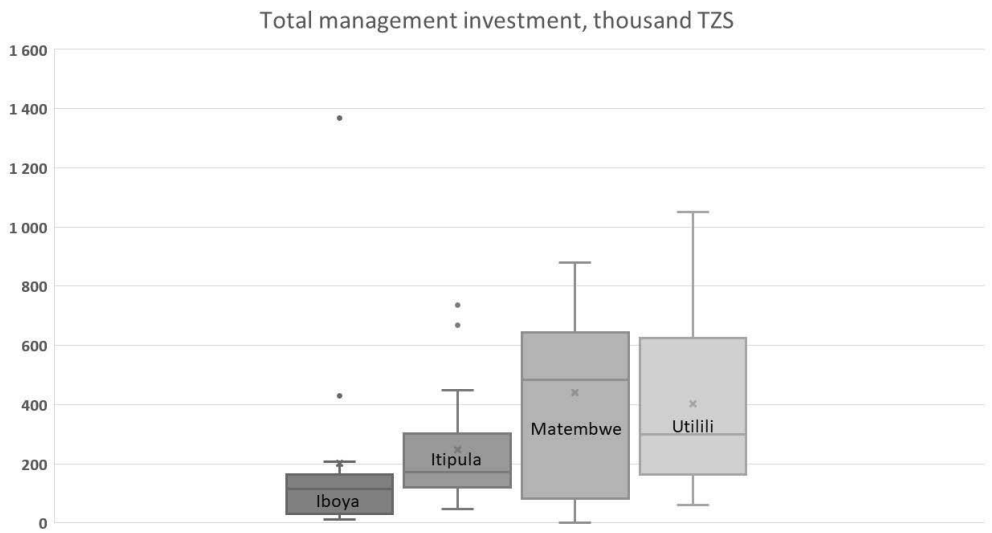

Figure 9. Comparison of the total plantation investment in the study villages

As an overall trend, the share of trees without defects decreased when the amount of forest management practices increased. In contrast, while the share of trees with severe defects was largely unaffected by the amount of forest management, the share of moderate and especially mild defects increased as more forest management practices were implemented.

Smallholder tree growers have a perception of pine as a short rotation species and as a result, rotation periods are too short from the wood quality viewpoint, with the overheated market supporting this (mis)conception. As in many other emerging smallholder tree growing systems, with their limited labour and financial resources farmers prioritize agricultural activities for food security over plantation management, and expect quick returns as they have no access to additional financing to invest more in tree growing and to prolong rotations (Kallio et al., 2012; Kallio and Kanninen, 2013; Nigussie et al., 2017).

Wood quality was assessed only visually in this study, but the interviews with wood traders and processors also indicate smallholder wood quality problems in the Southern Highlands. According to traders the smallholder-produced wood entering the market is juvenile, and knots caused by poor pruning practices or neglected pruning undermine technical qualities of wood.

Tanzanian smallholders were willing to invest their time, and in some cases also money, in tree plantation management, but an indication of willingness to perform plantation management does not necessarily lead to timely and competent implementation of management activities. Again, this is a result of inadequate technical knowledge, and of the prioritization of agricultural production over tree plantation management. Intercropping is often claimed to negatively affect tree stand growth and quality, but similarly to our findings, Muchiri et al. (2002) observed no such effect in measured woodlots. Instead, intercropping tends to ensure that weeding and early pruning are carried out properly and on time (Imo, 2009) as farmers do not need to allocate time separately for agricultural and tree growing activities.

4.1.4. Farmers' knowledge of and access to markets

In general, tree growers depend on local middlemen in wood sales, and they have thought of the sales channel before establishing their plantations. Two thirds of respondents stated that they already had an idea of their sales strategy at the time of planting the trees. Matembwe has the most established wood markets and all tree growers there had already identified a sales channel. Utilili, on the other hand, is further from the wood markets and has the least developed tree growing culture, but also there most of the tree growers had a

sales channel identified before planting their trees. Four interviewed tree growers (living in Iboya, Matembwe and Utilili) processed timber themselves. Tree growers did not consider wood sales or market access as major obstacles limiting their tree-growing interest, and none of the tree growers had paid any fees or licences related to tree growing or wood sales.

In Matembwe all - and in Iboya and Itipula nearly all (93% and 87%) - tree growers had already sold trees, or in three cases, a standing plantation. Utilili differed from the other villages, as only one-third of tree growers had sold trees so far. Tree age at the time of sales varied from 3 to 18 years, but only 25 respondents could specify the age of trees sold. Out of these 25 sales, the average tree age at time of cutting was 10.7 years. Based on this small sample it seems that on smaller farms trees are more likely planted on agricultural land using *taungya*, or, they are more likely to rely on wood sales for acute cash needs, and trees are therefore likely to be sold at a younger age: Figure 10 illustrates the significance of the area-age dependency ($R=0.88$, $p<0.001$), which reflects the pressure to return the land to agricultural use, and the lack of alternative income sources.

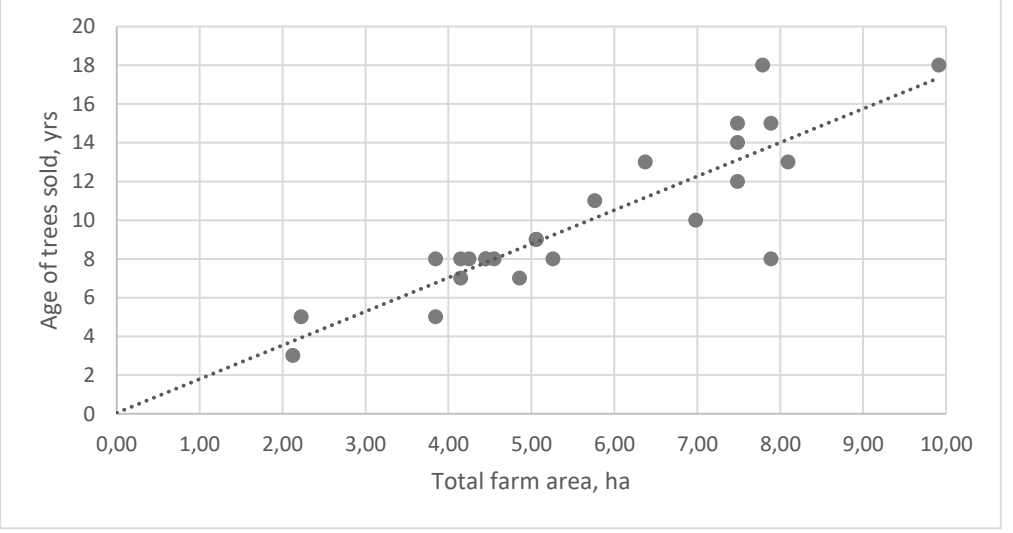

Figure 10. Relationship between farm total area and age of trees sold in the study villages in Tanzanian Southern Highlands

Approximately half (47%) of the interviewed farmers said they had some information concerning market prices at the time of sales. The knowledge of market prices at the time of the sales had been the best in Itipula (75% of wood selling tree growers in the village) and Matembwe (71%), as Itipula is close to the main road and Matembwe had an extension project since 2010 and a rather developed timber business in the village. Selling to a sawmiller (operating with mobile machinery) was the most common sales channel in Iboya and Itipula, while it was more common in Matembwe to sell to a middleman living in the village. A few (4) respondents had their own sawmilling business.

Interviews with wood traders indicated that in reality, two parallel value chains for pine-sawn wood actually exist in the Southern Highlands. Larger sawmilling industries source their timber from mature industrial plantations and rely heavily on the Sao Hill government plantations, even though they have started to establish their own plantations as well. Instead, smallholder-produced timber is processed on-site with transferrable machinery operated by micro-entrepreneurs, but this value chain produces lower quality sawn wood. At the time of the field research in 2015, high timber demand, wood scarcity, and farmers' needs for cash had led to a situation where wood from smallholder plantations is harvested before maturing, which further increases the quality differences between the two value chains.

Even though the smallholder tree growers did not consider access to markets as a constraint for tree growing, the wood market system is still undeveloped. Smallholder grown trees are sold without any inventory based on a visual assessment. Plantation location i.e. access roads and terrain also influence the pricing: the more challenging the logging, processing and transportation of sawn timber from the site, the lower the price paid for the farmer.

Based on the growth data of the measured stands, we can estimate that most stands sold fall in the 11–20 cm category and only few in the 21–25 cm category. The price paid for the two 18-year-old stands gives an indication that their diameter has been in the 26–30 cm category or higher. The price paid per tree on these mature stands is considerably higher than the government stumpage price per tree in the same diameter category (Table 10). However, it must be noted that the data collected on previous sales is thin and the risk of tree growers giving inaccurate or incorrect answers related to the stand age at the time of sales, for example, is rather high. The very limited data do not allow drawing wider conclusions on the prices paid, and more studies are clearly

needed concerning stand value growth, price formation and payment capacity in the pine value chain.

Table 10. Pricing of pinewood in Sao Hill plantations and prices paid for smallholder-grown wood in the study villages (Conversion rate 1st of May 2015 1 USD = 1 929 TZS)

The stumpage price in Sao Hill during the 2015/16 season		**Prices paid to smallholder growers 2008–2015**	
Diameter class (cm)	Total price per tree TZS	Age of trees at time of sales	Price per tree TZS
11–20	5 700	7–10	1 250–11 330
21–25	11 300	11–15	2 000–10 000
26–30	28 300	16+	57 143–115 700

4.1.5. Future investments

In Tanzania the supportive mechanisms for smallholder tree growers are under development and it is yet to be seen how successful they are in enhancing smallholder knowledge and capacities, for example in responding to quality needs and market trends. However, it is surprising how effectively smallholders responded to the increased demand for wood and captured the livelihood opportunity in the early 2000's.

Smallholder tree growers are highly interested in continuing and expanding their tree growing business in the study area. Nearly all (93%) of the interviewed tree growers stated that they intend to plant more trees in the upcoming five years, although 39% of them will plant more trees if they have available land, and 6% mentioned that they will increase their plantations if they are able to purchase more land. Pine was the preferred species due to the ready markets and its marketability (80% of respondents), and secondly due to its rapid growth and quick returns (32%). Approximately half (53%) of the non-growers stated that they will, or most likely will, plant trees in the upcoming five years, while 17% of non-growers stated they will with the precondition that they have access to additional land. The main reasons non-growers listed to justify their lack of interest for tree growing were land shortage (29%), old age, or health problems (24%). Priorities in using the income from tree growing varied slightly between tree growers and non-growers. Tree growers had children's education as their priority (77% of respondents), whereas the majority of non-growers prioritized building or repairing a house (28%) before children's education (14%) (Table 11).

However, this may reflect at least partly the age structure difference between the two groups and not necessarily their real priorities.

Table 11. Tree growers' and non-growers' priorities in investing the money from tree growing

	Tree growers (N=60)						**Non-growers (N=36)**				
Priorities for investing tree growing income	1st	2nd	3rd	4th	5th	Total	1st	2nd	3rd	4th	Total
Send children to school	46	5	2	1		54	5	12	1		18
Build/repair a house	3	12	5	1		21	10	2			12
General home/family use	4	25	7	1		37	3	2	3	1	9
Emergencies	1	1	0	1		3					0
Car/motorcycle	0	2	2	0	1	5			1		1
Travel	0	0	0	1		1					0
Healthcare	0	0	1	1		2		1			1
Invest in a business	2	5	2	1	1	11	1		1		2
Purchase more land	1	0	2	2		5					0
Savings	1	0	5	0	2	8	3	1	2		6
Plantation/farm-related investments	1	2	6	2		11	2	3	4	3	12
No clear answer	1					1				2	2

Tree growing has increased in the study villages and among the interviewed smallholders every year since 2010, but planting levels dropped in 2015. Possible explanations for this could be decreasing availability of land, but could also indicate speculation with expected support from the recently launched Private Forestry Programme. Smallholders in the study villages are aware of the programme and expect to receive support such as free seedlings in upcoming years and are therefore not investing their own money and resources into tree growing.

Interest in tree growing and expanding tree growing areas is very high among smallholders in the Southern Highlands. For the time being, lower than average population (National Bureau of Statistics, 2013), land availability, and favourable climatic conditions make tree growing possible and feasible in the Southern Highlands. Access to land, not the cash income, defines households' interest to plant trees, which is in line with the findings of Kulindwa (2016). Land use pressure induced by population growth and escalated by the likely

impacts of climate change (United Repubic of Tanzania, 2015) will remain high in Tanzania for years to come, while increasing pressure for more agricultural land is likely to push tree growing into more remote areas and poorer sites, where expected returns on tree growing are smaller due to longer rotation ages and/or lower stocking rates that may need to be applied (Call et al., 2017b; Capitani et al., 2016). Land holdings are likely to fragment and shrink further due to the subdivision of land for descendants, further escalating the pressure to shorten rotations, especially on plantations established on agricultural land.

4.2. Effectiveness of government policies and incentives in stimulating smallholder tree growing in Lao PDR (Paper II)

4.2.1. Socioeconomic characteristics of the interviewed tree growers and non-growers

As a whole, tree growers' and non-growers' groups did not significantly differ socioeconomically, but there were differences in income and agricultural land within the non-growers group. On average, tree growers had more land and they were also more often using external labour in farming activities (Most households had cash income both from agricultural crops and livestock (farm income), and businesses and/or labour work. According to the rough estimates the interviewees provided on the share of each income source, in the tree-growers' group the share of farm income was larger, as 58% had farm income as the main income source (i.e. ≥50% of their income), with the remaining 42% reporting that business and labour work were the most important income sources. Income from timber sales is significant but occasional, with timber sales often taking place only when the household needs to invest or has unexpected expenses, or when the owner receives a tempting offer from a buyer. In the non-growers group households depended more on business and labour for their income due to their limited or non-existent land resources: the shares were 22% from farm income and 78% from business and labour work. Variation between villages was large (Figure 11), reflecting local availability of work and business opportunities, and land availability.

Table 12). In the non-growers' group 28% of the households had no land, and 17% had less than one hectare, but also the wealthiest interviewees - both in terms of land and income - were in the non-growers group. Land tenure is rather formalized as nearly all interviewees in both groups (89%) had formal land rights either through occupancy or permanent land title. The share of landless families was especially large in the non-grower groups in Phialat and

Ban En villages, leading to significantly less rice self-sufficiency among non-growers.

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Table 12. Household socioeconomic characteristics in the study villages in Lao PDR (KIP conversion rate 1 November 2015: 1 USD = 8 115 KIP)

	Tree growers (N=62)					Non-growers (N=54)				
Household characteristics	**%**	**Min**	**Max**	**Mean**	**St.dev.**	**%**	**Min**	**Max**	**Mean**	**St.dev.**
Age of HH head	-	30	75	52.4	11.8	-	19	73	45.9	11.6
Education										
Not completed primary school (%)	34	-	-	-	-	33	-	-	-	-
Completed primary school (%)	23	-	-	-	-	15	-	-	-	-
Vocational/secondary or more (%)	37	-	-	-	-	50	-	-	-	-
Not available	6	-	-	-	-	2	-	-	-	-
Family size (members)		2	9	4.34	1.83		2	10	5.02	1.67
Income, millions Kip/yr		5	150	39	27.7	50	3	400	35.9	56.5
Income per capita, millions Kip/YR		0	60	11	10.5	48	0	100	8.2	14.4
Agricultural area		0.0	13.0	2.1	2.1		0.0	21.0	1.4	2.9
Share of HHs with sufficient rice %	74	-	-	-	-	39	-	-	-	-
Using external labour % (those farming)	69	-	-	-	-	33	-	-	-	-
Plans to sell the farm %	32	-	-	-	-	21	-	-	-	-
Has land title %	89	-	-	-	-	89	-	-	-	-
Share of land planted for trees		2	100	40	27		-	-	-	-
No. of woodlots		1	6	2.03	1.23		-	-	-	-

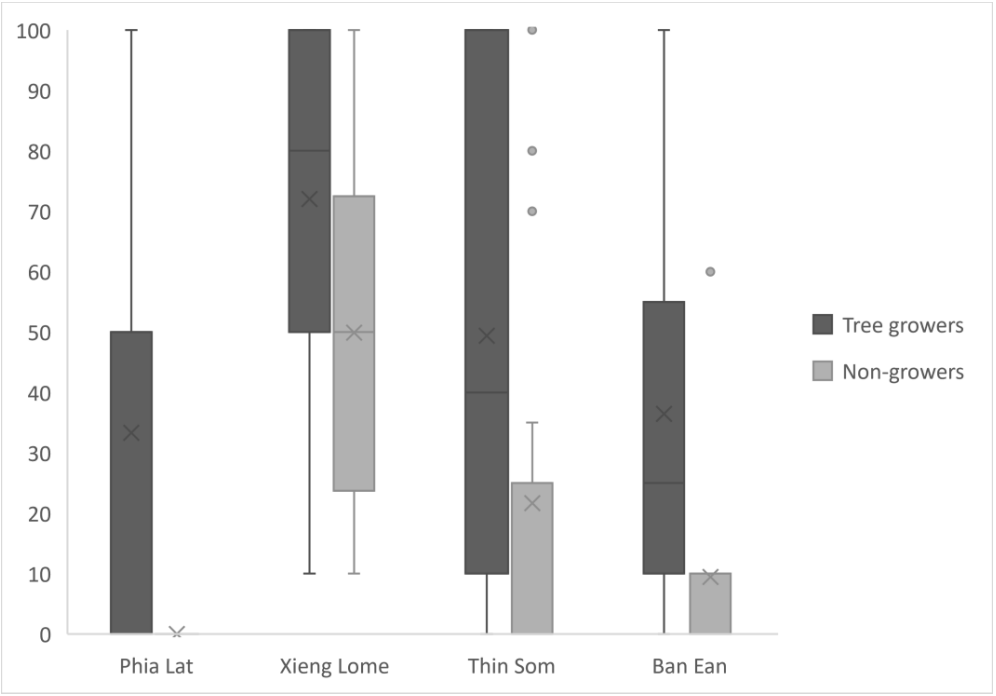

Figure 11. Share of farm income (%) of the total household income, comparison of the study villages in Lao PDR

4.2.2. Smallholders' response to changes in forest policy and legal framework in the study villages

Policy and legal framework in 1990-2015

The Land and Forest Allocation Programme, evolving into the Land-Use Planning and Land Allocation programme (LUPLA) in the early 1990's, combined land use and privatization targets to increase land tenure security. Land tenure reforms were introduced in the 1991 constitution and affirmed in the *No. 99/PM Decree on Land* in 1992 thus enabling farmers to invest in their land. The Prime Minister's Decree (PM Decree No. 169/1993) recognized and established rights of individuals, collectives, or juridical entities on trees they plant or maintain with their own labour or capital. A specific decree on Allocation of Land and Forest Land for Tree Plantation and Forest Protection (PM Decree No. 186/1994) promoted allocation of degraded and bare land for plantations, specifying fast growing species and teak as preferred species, and introduced land tax exemptions and exemptions on wood sales royalties and

charges (excluding income tax) for the planted forests and agroforestry systems.

The several decrees were further consolidated into a national program under PM Decree No. 3/1996, which also recognized villages right to manage large forest areas, calling for village boundary demarcation and division of land as forest or non-forest. Land Tax rates were set in 1993 but exemptions were provided for long term industrial tree plantations for years 2-5. Directive No. 0234 of the Minister of Agriculture and Forestry 'Management of plantations and planted forests' in 1995 introduced the procedure to acquire documentation and registration of a tree plantation required for the land tax exemption and exemption of the forest restoration and forest resource fees. Tree plantation registration requirements and procedures were specified by regulation in 1999 (No. 1849/AF).

The Land Law 1997 (rev. 2003) limited the land area available for agriculture per family thus aiming to promote permanent agriculture. In addition, a household could enter into an agreement to manage and use degraded forest or non-forest land for agriculture, forestry and livestock production. Permanent tenure of the degraded lands could be received after three years if the conditions of the contract were met. Any planted trees or rehabilitated forest belongs to an individual or the organization who has planted them, provided they have state recognition and the required approvals or licences for utilization (Sacklokham and Dufumier, 2006; Smith et al., 2017b; Smith and Alounsavath, 2015).

The Forestry Law 1996 (National Assembly, 1996), which replaced the several Decrees given in the early 1990's, and the Land Law 1997 (amended in 2003) reconfirmed the state ownership of natural resources, separated agricultural and forest lands, and described different forest land uses. It also set the legal framework for land use planning and allocation (Newby et al., 2012; Phengsopha and Fujita, 2012; Poffenberger, 1999), established the ownership rights of planted trees and limited the maximum tree planting area on degraded land per family. District Agriculture and Forestry Offices (DAFO) were made responsible for the authorization procedure. The law also required registration of forestry activities according to the Business Law (National Assembly, 1996).

The Forest Law was revised in 2005 and again in 2007 (Lao People's Democratic Republic, 2007) but these revisions did not bring any changes in the tree growing setting. As an example, tree plantations are still included

under the production forest category and not classified separately (Smith, 2014). The Forest Law 2007 is presently under revision process, as is the Land Law from 2003.

Smallholder teak planting in the study villages in 1990-2015

Variation in teak planting between years is large and may be affected by, for example, weather conditions. However, some increase in teak planted areas in the study villages can be observed in 1993-1995, 2000, and again in 2005-2008 (Figure 12). No major differences are identifiable between the villages, although less woodlots were established in Phialat than in villages in Luang Prabang Province during the first peak. Only a few of the tree growers had rubber plantations, or tree plantations other than teak.

Household teak woodlots are very small, with nearly 60% of woodlots owned by the interviewees being smaller than 1 ha, and an average plot area of 1.1 ha. Most of the interviewed households had one (45%) or two (26%) woodlots, with six being the maximum number of woodlots of any household.

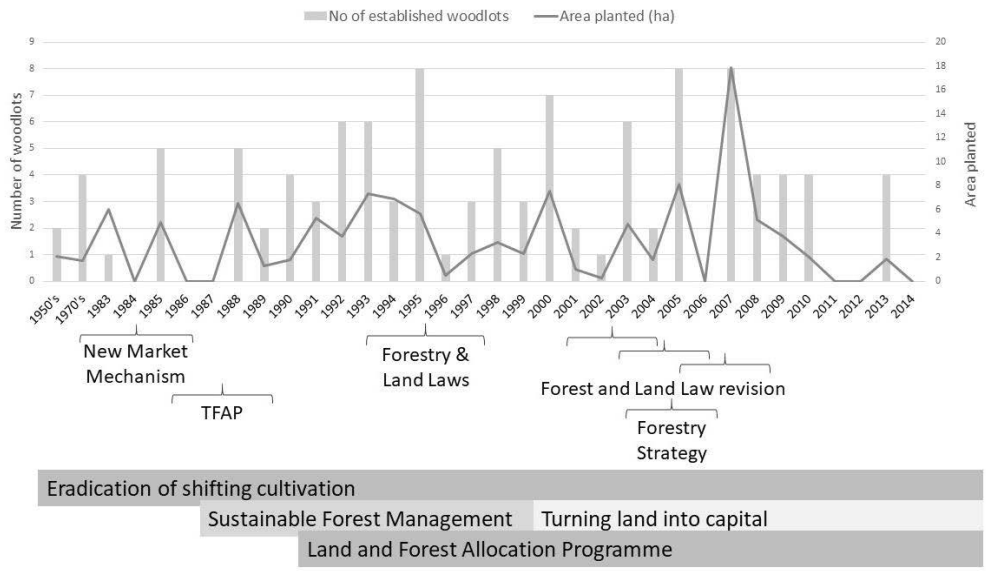

Figure 12. Development of policy and legal framework vs. tree growing among interviewed smallholders in the four study villages in Lao PDR.
Y1 axis (no. of woodlots) is the total number of new woodlots established and Y2 axis (area planted) is the combined area of the newly established woodlots planted per year.
TFAP - Tropical Forestry Action Plan
New Market Mechanism - economic reforms opening the markets

Teak requires fertile soil thus it is not surprising that the majority of the woodlots are on former agricultural (59%) or fallow land (20%). The rest have been established on former grass or grazing land or are replanted tree plantations. Seedlings had been mainly produced from stumps prepared from wildings collected from existing plantations in the village. Intercropping is common, with 81% of tree growers having planted agricultural crops (e.g. rice, Job's tears[2], pineapple) during the first years of tree plantation establishment. Teak woodlots were managed quite intensively, as the majority of interviewees (89%) carried out regular weeding, slashing, and pruning of their woodlots. However, only one third (29%) did thinning, with observations in the field indicating that the intensity of thinning is low, meaning removal of a few individual trees only. Only five of the interviewees who practice thinning mentioned having received extension advice on the topic. A common practice among smallholder tree growers is to let the teak plantations coppice after a selective cut (harvesting for sale), which was observed at some of the visited woodlots.

Teak is grown primarily for timber sale (69% of all respondents), with one third also mentioning own use as a secondary purpose. Some 17% of the tree growing households were growing teak for the household use, mainly to be used as construction wood. Several interviewees, including village head men, stated that the village forest resources are degraded and cannot supply the villagers with enough timber. Only one tree grower mentioned that tax exemption benefits had been a motivation to plant trees, and none of the interviewees mentioned the option to use their tree plantations as collateral as a motivator to plant trees.

Preferences for future tree growing varied between provinces and villages (Table 13). Although the tree growers had reasonably high interest to expand their tree growing area in Phialat (Vientiane Province), most of them were planning to change species from teak to fruit trees or Dipterocarps. In Ban En tree growers preferred teak for their future/planned tree growing, whereas in Thinsom and Xienglome some teak growers were planning to change species, mentioning oil palm and Dipterocarps as alternatives. Interest to expand tree growing area was the lowest in Xienglome, reflecting constraints in land availability, which was listed as the main reason not to plant trees in all

[2] Scientific name *Coix lacryma-jobi*

villages. The majority of tree growers (63%) considered agriculture, (cash crops including fruit trees and oil palm) as a more profitable land use because of the steady, annual income.

Table 13. Tree growers' interest to expand the tree growing area

Planting more, %	Phialat	Xienglome	Thinsom	Ban En	Mean	Standard deviation
Yes	7	7	31	6	13	12.2
Most likely yes	53	7	6	19	21	22.0
Replanting only	0	27	31	31	23	15.0
Most likely no	0	0	0	13	3	6.5
No	27	47	31	31	34	8.9
Don't know	13	13	0	0	6	7.5

It was clear among the tree growers that the (land) tax exemption benefits for tree plantations are not significant or feasible from the smallholder perspective as they were only mentioned once in the interviews as a benefit in tree growing. There is also a practical reason for this: most of the woodlots are too small to qualify for the exemption. Most tree growers said that if available, they would apply for incentives such as extension services and tools or seeds/seedlings.

One third of the non-growers expressed interest to grow trees in coming years; the main reason for not being interested in tree growing was lack of land (Table 14). In this study, we did not identify clear dependencies between the socioeconomic factors and tree growing interest, but the decision is a complex combination of factors. The main motivation for future tree growing in both groups was to increase income or to leave assets for children. Teak was clearly the most preferred species among non-growers, but rubber and fruit trees were also mentioned. Most of the non-growers said they have enough tree growing knowledge and that they are aware of the incentives. For technical advice they would turn to other villagers or the District Agriculture and Forestry Office. Only 15% of the tree growers that were interested in expanding their tree growing area considered incentives (extension, seeds/seedlings) to have a significant influence on their decisions about tree growing. In the non-growers' group only one interviewee said incentives are important, although most of them were interested in applying for them, if available.

Table 14. Non-growers' interest to plant trees in the coming five years (excluding oil palm) (Total 46 answers)

Planting in next 5 years, %	Phialat	Xienglome	Thinsom	Ban En	Total	Standard deviation
Yes	0	13	13	0	9	7.5
Most likely yes	11	13	27	29	20	9.3
Maybe	22	13	20	0	15	9.9
Most likely no	0	7	13	0	7	6.3
No	56	47	27	43	41	12.1
Don't know	11	7	0	29	9	12.4

4.2.3. Common challenges in tree growing

One-third (34%) of the tree growers reported no problems in tree growing. Lack of knowledge and harm from grazing animals were the most commonly mentioned problems among tree growers (18% and 13% of the respondents) (Table 15). The main concerns among non-growers (interested in tree growing) on tree growing were the long time before the woodlots produce income and reduced availability of agricultural or pasture land (mentioned by 54% and 25%).

Slightly more than half (55%) of the interviewed tree growers had received forestry extension services, mainly through a project or programme implemented with external (donor) finance. Very few interviewees (11%) mentioned district forestry extension as the source of services. Extension services received had focused on early management, pruning, and thinning.

The Luang Prabang Teak Programme (LPTP) program supported the establishment of Tree Growers' Associations (TGAs) between 2008 and 2014 in Ban En and Xienglome, where 69% and 53% of the interviewed teak growers are TGA members respectively. In Thinsom, a non-LPTP village, 56% are TGA members, in Phialat there is no TGA in the village. Very little reference was made to the association and the interviewed teak growers seemed to consider membership as a precondition to access LPTP support services.

Table 15. Encountered and anticipated problems in tree growing among tree growers and non-growers planning to plant trees in Lao PDR

Problems encountered (tree growers) or anticipated (non-growers)	**Tree growers, % (N=62) (encountered)**	**Non-growers interested in tree growing, % (N=19)[3] (anticipated)**
No problems	34	47
Inadequate knowledge	18	7
Harm from grazing animals	13	4
Deterioration of landscape values	10	4
Land grabbing	8	4
Low teak selling prices	6	0
High tree mortality	5	7
Wind damage	5	0
High investment risk	3	21
Complicated procedures with authorities	3	0
Conflicts with neighbours of land use	3	0
Excessive amount of work	2	7
Too much shade	2	7
Illegal logging/stealing	2	7
Soil erosion	2	14
Other soil-related problems	2	7
Reduced availability of agricultural/pasture land	0	25
Long period before trees produce income	0	54
Poor availability of seedlings	0	4

Teak growers were actively managing their plantations and regularly carried out weeding, slashing, and pruning. They also often practised intercropping

[3] Number of non-growers giving the answer 'Absolutely', 'Most likely' or 'Maybe' regarding their tree growing interest in the coming five years.

during the early years of the plantation (taungya), which partly explains the diligent weeding practices. However, thinning, which is a critical management practice for diameter and value growth of teak, was rarely done.

Tree plantations were not systematically measured for this study, thus the information on quality is based on key informant interviews only. Based on the buyer interviews – and previous studies –challenges related to quality are significant, as smallholder tree growers do not apply professional plantation management practices and they tend to sell lower quality wood for lower prices.

Plantation management practices have remained the same over the years thus advisory services have not sufficiently been available, reached, or convinced tree growers to improve their practices. The prevailing management and sales practices leave them with thinly stocked, low quality, and unproductive teak plantations that increases the comparative advantage of other land uses.

4.2.4. Market access

Smallholder wood sales are taking place mainly through middlemen and through selective cutting. Nearly half (48%) of the tree growers had sold teak at least once (between 1997-2014), mostly some dozens of trees of 20-30 cm diameter to a middle-man, or in some cases directly to a wood processor/manufacturer. Despite the classification of Ban En[4] as a remote village, there was a wood processing enterprise in the village and several export oriented larger processors near the village. Inventories for wood sales was rarely done (although it is required by law), and varying methods were used for measuring trees and setting prices.

Overall, the interviews with middlemen and tree growers revealed that tree growers had very little room to negotiate in the sale of their wood. Middlemen rarely bought all the trees (i.e. clear cutting was rare), but instead the contractor used for the harvesting work selectively cut the best quality trees. The owners were left with the remaining trees to grow, and stumps to regenerate new trees via coppicing. Sometimes middlemen also bought trees in advance to be harvested later if the seller needed more money than received from the mature,

[4] Official village name is Ban Ensavanh, spelling forms of the shortened name used include ‘Ban Ean’ and ‘Ban Enh’. Google maps uses the shortened name ‘En’.

higher quality trees available at the time of sales. Also, whole plantations (including land) had been sold in times of urgent cash needs.

Despite their weak negotiation position, the teak growers reported that the process of selling their wood was quite easy, and middlemen easy to contact and work with. Neither did the non-growers list market access as a constraint limiting their interest in tree growing. Tree growers considered the services middlemen provide essential, as they took the responsibility of the bureaucratic process. Even though the Luang Prabang Teak Programme has been working to establish and extend the sales network with middlemen, only four interviewees mentioned having received extension support in wood sales or measurement.

The interviewed forest industry representatives reported that teak prices are higher in northern Laos due to the influence of Chinese traders and plantation investments. This is also visible in the disappointing sales experiences that tree growers mentioned in Phialat (in central Laos), where local traders offered relatively low prices for teak.

Reforestation, together with sustainable forest management, has been high on the political agenda in Lao PDR since the early 1990's. Smallholder tree growing has been recognized in policies, but in policy implementation industrial scale concessions have received more attention. Measures targeted to incentivise smallholder tree growing have remained basically the same since the 1990's, as well as the tax exemptions for tree growing. Attempts to build a comprehensive legislative framework for smallholder tree growing have resulted in a complex jungle of laws, orders and regulations (Smith et al., 2017c), which keeps many of the tree growing activities in the informal side of the economy. Even though the law revisions since the 1990's seem to have created secure enough land and tree tenure and induced teak growing in the study villages, the complex regulations have counteracted the land incentives (Smith et al., 2017b).

Even the most effective incentive for smallholder tree growing, land allocation, is becoming void as smallholder farmers do not have access to more land in reality. The land and forest classification, zoning and allocation process is complex and multi-layered including steps at the National, Provincial, District and Village Levels. The regulation given in 2007 (*No 564/NLMA Adjudication of Land Occupation and Rights)* and in 2010 (*PLUP Guidelines* and *No 1374/MCAF Plantation Registration Certificates)* given to clarify the process and responsibilities within the process (Department of Forestry Inspection and

Departnment of Forestry, 2016; Smith, 2014) has not achieved its purpose. Despite high demand for teak from China (Midgley and Mounlamai, 2015), demand for many agricultural crops is also high, and due to their shorter rotations they are often a more attractive land use option for smallholders. In teak plantations intercropping is therefore a common practice to create income also during the first years of the tree plantation (Midgley et al., 2007).

Laos launched the smallholder tree growing promotion policy at the same time with Vietnam, but the scale of the outcomes is very different between them. Both countries provided access to land, but in Vietnam the land incentive was combined and supported with other incentives such as loans, a seemingly important addition which the Lao government failed to deliver to smallholders. The Vietnamese government's role in creating the market demand is another important factor to consider, with forest policies supporting smallholders combined with policy instruments to support forest industry development. It is worth considering to what extent smallholders in Vietnam and Lao PDR joined the smallholder tree growing programmes simply to access the available land, and only later started to consider tree growing as a feasible livelihood option.

Even though teak is grown primarily to create additional income through timber sales in Lao PDR, domestic use was also found to be an important factor, as Hansen's study (1997) also found. For example, Newby et al. (2012) reported securing land rights and using plantations as collateral as being key motivators for tree growing, but in this study they were not mentioned by the interviewees. However, this study focused on smallholders living in the study villages, while it is the who absentee land owners (often urban dwellers) are more likely to establish teak plantations to secure their land tenure rights.

Based on our findings the land use planning and land allocation in Lao PDR program as it is implemented now no longer allows smallholders access to additional land for tree growing, even though tree growing areas among the interviewed households rarely reached the limits set in the legislation for the maximum area per capita. Whether this is due to complexities in the allocation procedures, lack of awareness, land scarcity, land conflicts, quality of available lands, or authorities' reluctance, are questions that need further research. The majority of the woodlots owned by interviewed farmers are not eligible for exemptions because they are unregistered. Due to their small size, plantation registration is simply unfeasible as the annual land tax is low compared to the registration payment (Smith et al., 2017c). Additional tax benefits for TGAs and their members seem to be equally negligible. This is in line with findings

of Ling et al. (2018) who showed that the benefits the TGAs are able to provide vs. the time invested in TGA activities are not sufficient to attract smallholders' interest.

4.3. Qualitative Comparative Analysis – What drives smallholder tree growing? Enabling conditions in a changing policy environment (Paper III)

4.3.1. Country background

The following sections give a short description of country-level information. Detailed country data set matrixes used in the analysis are available at Mendeley Data (http://dx.doi.org/10.17632/nz252wbjyn.1). Table 16 below gives a general overview of smallholder tree growing and the forest sector in case-study countries in 2015.

Table 16. Overview of the status of smallholder tree growing in case countries in 2015.

	Introduction of smallholder tree growing incentives	Present estimate of smallholder tree growing area	National - level wood scarcity	Total forest area change	Strong forest industry sector
Indonesia	Varying incentives since late 1970's	2.8 million ha	No	Decresing	Yes
Laos	Early 1990's	215 000 ha	No	Decreasing	No
Tanzania, Southern Highlands	2014	160 000 ha	Yes	Decreasing	No
Uganda	2004	30 000 ha	Yes	Decreasing	No
Vietnam	Early 1990's	1.8 million ha	Yes	Increasing	Yes

Tanzania

Tanzania is a former socialist country classified as a least developed country. Despite the annual economic growth of 5-8% in last 25 years (The World Bank, 2016), the majority of people live with less than US$2/day. Population growth is high and has varied between 2.7 and 3.15% between 1990-2015. Agriculture and forestry production rely heavily on smallholder farmers,for example 98% of the country's maize is produced by them (IFAD, 2010; Minot, 2010; World Bank, 2016). Modernization and commercialization strategies for

improving agricultural productivity have been unable to meet the 10% annual growth target set by the government, and this growth has barely met the pace of current population growth (Haug and Hella, 2013).

Tanzania is one of the top ten countries experiencing the greatest annual net forest loss between 2010–2015 (FAO, 2015a). The main drivers of deforestation are agricultural expansion, charcoal production and fuelwood, and (illegal) logging of high-value timber between the 1980's and 2012. The present annual allowable cut of 0.95 m^3/year/capita cannot meet the average demand for wood, estimated at 1.39 m^3/year/capita (MNRT, 2015). A supply shift from wood originating from natural forests to plantation-grown softwoods began in the late 1990s (Wells and Wall, 2005), when natural hardwood prices were rising due to diminishing sources. Government forest plantations are still the main source of industrial round wood, but these resources are in sharp decline (Ngaga, 2011). This wood scarcity has created a livelihood opportunity for smallholder farmers, with the area of smallholder tree plantations rapidly increasing in the Southern Highlands of Tanzania in the last 10 years (Mankinen et al., 2016).

Government forest policy (MNRT, 1998) and climate change strategies emphasize the role of private sector involvement in forest management and strengthening nation-wide tree-planting programmes (United Repubic of Tanzania, 2015), but resources to implement these policies and strategies are limited. Only recently have the first donor-supported initiatives to support smallholder tree-growing activities, such as the Private Forestry Programme and the Forestry Development Trust, begun their work in the Southern Highlands.

Lao PDR

Lao PDR (Laos) is a socialist state which has, since the 1975 revolution, followed a similar path in introducing economic reforms as Vietnam, starting in the early 1990's (Bird and Hill, 2010). Major drivers for economic growth have been hydropower projects producing electricity for neighbouring countries, and high demand for agricultural products from Vietnam and China, which has turned Laos into a resource frontier in the region (Kallio et al., 2019; La-Orngplew, 2012; Lestrelin et al., 2012). Despite the growth, Lao PDR is still categorized as a Least Developed Country in the UNCTAD reporting.

Agricultural productivity has increased, especially in the last 10-15 years, and population growth has slowed down from 2.9% in 1990 to 1.3% in 2015. Although the majority of the population (>60%) is still rural, urbanization is

rapid. Laos has been known for its forest resources but deforestation and especially forest degradation have been serious (Fujisaki, 2012). Especially in the 1990's Laos' major export income source was timber, with the high level of illegal logging accelerating the depletion of their forest resources (Saunders, 2014).

Land and forest resources' significance in the national economy has been recognized in national policies since the late 1980's. As a part of their economic reforms, Laos introduced land allocation programmes in the early 1990's that encouraged smallholders to plant trees to access more land (Lestrelin et al., 2013). These policies have not been able to halt deforestation though, although the pace of deforestation has reduced from the 1.4% in the 1990's to some 0.5% in the 2000's (Fujisaki, 2012). At the same time plantation forest area has increased from an estimated 10 000 ha in 1990 to some 446 000 ha in 2016 (Earth Systems, 2016; Hansen et al., 1997). Rubber plantations make up more than 50% of the plantation area increase. The share of trees planted by individual farmers and entrepreneurs in this increase is estimated to be 48%, but the figure is only a rough approximation since only some 10% of smallholder plantations are registered (Smith et al., 2017c).

Indonesia

Indonesia has been categorized as an emerging middle-income country since the early 1990's. The economy and governance have gone through drastic changes after the collapse of the Suharto regime in 1998. Economic growth has been fluctuating, especially in 1980's and 1990's, but has mainly exceeded 5% annually. However, regional differences between islands are large in terms of livelihoods, deforestation and land tenure (Akita, 2002; Susanti and Maryudi, 2016). At the national level population growth has declined from 1.8% to 1.2% between 1990 and 2015, with more than half of the population (54%) living in urban areas.

Indonesian agricultural policies have strongly promoted and incentivized cash crop cultivation and irrigation system development for rice cultivation (Erwidodo et al., 2009). Rubber has been a traditional cash crop for Indonesian smallholders and communities, but the extent of the oil palm cultivation that started in the 1990's overshadows rubber cultivation in terms of expansion and the income it provides, not only to industrial operators but also to smallholder producers who presently manage some 40% of the oil palm area (Gatto et al., 2015; Susanti and Maryudi, 2016).

Large scale industrial tree plantations were strongly promoted during the Suharto regime until the 1990's, with questionable outcomes as it seemed to accelerate deforestation and violated traditional land tenure. Since then, increasing attention has been given to support smallholder and community forestry, but the outcomes have been very different across the country's different islands (Permadi et al., 2018). Farm forestry on private lands has increased considerably, for example between 2003 and 2010 from 1.56 million ha to 2.8 million ha. Most of the increase has taken place in Java, whereas in Sumatra and Kalimantan smallholder tree growing has not become such an important livelihood option (Kartodihardjo et al., 2013), with oil palm expansion dominating smallholder land use instead (Gatto et al., 2015).

Uganda

Uganda is one of the poorest countries in the world, despite the significant progress made in reducing extreme poverty, which decreased from 53.2% in 2006 to 34.6% in 2013. This improvement is mostly due to an increase in agricultural income created with the support of favourable weather conditions and prices, and political stability (Kjær and Joughin, 2012). Despite the economic growth, the benefits of the growth are not equally distributed, with living standards such as access to sanitation and electricity remaining poor (Daniels and Minot, 2015). At the same time, rapid population growth continues at a rate varying between 3.2 and 3.5% between 1990-2015 (World Bank, 2016). Even though agriculture's share of the GDP has been in decline, the majority (69%) of the population still relies on agriculture for their subsistence and livelihoods, thus the Ugandan government is investing in agriculture and its commercialization with, for example, subsidies (Joughin and Kjær, 2010; Kjær and Joughin, 2012; MAFAP, 2013).

Deforestation in Uganda has been drastic since the 1990s, with forest cover decreasing from 24% in the 1990's to 8% in 2018 (Josephat, 2018). Forest policies and revision of laws in the early 2000's were attempts to address the deforestation problem (Galabuzi et al., 2015). However, as 90% of the population depends on wood for their energy, and economic growth has fuelled wood consumption (e.g. in the construction sector), the deforestation has continued, despite (illegal) imports from Congo DRC (EU-FLEGT Facility, 2014). In addition to natural forest conservation and sustainable forest management objectives, policies and a new forest act also strongly promote tree growing. An EU-funded support programme - Sawlog Production Grant Scheme (SPGS) - was launched in 2004 and has continued to date. Since the launching of the SPGS tree plantation area has increased to some 100 000 ha,

of which smallholder plantations make up some 20 000-30 000 ha (Tugumisirize, 2017).

Vietnam

From 1986 Vietnam has implemented an economic reform program 'Doi Moi' that has turned the country from communism to so called market socialism, and driving the transformation from a least developed country to an emerging middle-income nation. GDP has been growing steadily with the annual rate exceeding 5%. The majority of the population still lives in rural areas (>60%), although urbanization is rapid and population growth has slowed down between 1990 and 2015 from some 1.5% to 1%. Agricultural productivity increased especially in the 1990's, giving a push for structural change (McCaig and Pavcnik, 2013).

Vietnam has managed to turn net forest lost to forest area increase. According to World Bank records, the forest area has increased from 29 to 48% between 1990 and 2015, but regional differences are large: in northern parts of the country natural forest areas are regenerating but in central and southern parts deforestation continues, mainly due to agricultural (cash crop) expansion (Cochard et al., 2017). The Vietnamese government has strongly promoted and supported smallholder tree growing since the 1990's. Land allocation for smallholder farmers for tree growing has been part of the reform process and programs, such as the '5 Million Hectare Reforestation Programme'. They have strongly promoted tree growing leading to a substantial increase in smallholder tree growing area, which is estimated to be some 1.5 million ha (Sikor and Baggio, 2014).

4.3.2. Evolution of the enabling environment and smallholder commercial tree growing area in case-study countries

This section summarizes the changes of smallholder commercial tree growing area and evolution of the enabling environment in the case-study countries. Country matrixes are available via Mendeley Data (http://dx.doi.org/10.17632/nz252wbjyn.1), and include a more detailed description of the enabling environment by country, and provide the basis for the binary coding of the enabling factors (present – absent) applied in the QCA process.

The scale of smallholder commercial tree growing area expansion varies in the selected countries, as they represent diverse political and socioeconomic contexts and have applied different combinations of tree growing incentives. Vietnam and Indonesian Java have smallholder plantations resource of

millions of hectares. Smallholder plantation area in Tanzania and Uganda is increasing rapidly (although the total area is not yet significant), whereas in Lao PDR smallholder (non-rubber) tree plantations have developed at a considerably slower pace. In Indonesian Sumatra and Kalimantan, smallholder tree growing has been minor compared to the expansion of first the rubber and industrial-scale pulp plantations, and then oil palm. The challenge in estimating these changes lies in availability of reliable and coherent data on smallholder tree growing (Verdone, 2018), and therefore comparison of countries in the QCA is based on smallholder commercial tree growing trends; i.e. whether the area has been increasing, stagnant or decreasing.

Smallholder plantations may be established under various schemes in Indonesia but most of them are under *Hutan Rakyat* (smallholder private forest). Smallholder tree growing area has been increasing in Java since the 1970's, and between 2003 – 2010 the area of smallholder plantations increased from some 1.5 million ha to 2.8 million ha, of which some 90% are in Java (Rohadi et al., 2015).

Even though Lao PDR has a rather long history of teak plantations, there are no figures on the smallholder tree growing area in the past, or even today. Available documents and reports suggest that smallholder teak growing area has been close to nil before 1990, and the increase has been very slow (a few hundreds of hectares per year) until 2005. Since then, teak growing has slightly picked up pace reaching an estimated 50 000 ha in 2015 (Midgley et al., 2017; Phimmavong et al., 2009).

Little data available on tree growing in the Southern Highlands of Tanzania, especially from the past. However, based on the available reports and field research it can be said that before 2005 smallholder woodlots were very few, and mainly established for fire wood production (Acacia or eucalyptus) with the support of missionaries, for example. Since 2007 the smallholder tree growing area has rapidly been expanding, reaching an estimated 160 000 ha (Mankinen et al., 2016).

In the 1990's Uganda's commercial forest plantations were either owned and managed by the government or by the industrial private sector. Private commercial tree growing only started increasing after the introduction of the Sawlog Production Grant Scheme (SPGS) in 2004. The Scheme supports commercial tree growing from small to large scale owners, both on private lands and on leased land in Central Forest Reserves. By 2015 the total private forest plantations area is estimated to be up to 100 000 and smallholder

commercial tree growing area is estimated to be around 20 000 - 30 000 ha (Tugumisirize, 2017).

Economic reforms, land allocation, and reforestation campaigns have turned net deforestation to increasing forest cover in Vietnam (Meyfroidt and Lambin, 2008). Forest area has increased from some nine million ha (natural forest and tree plantations) to approximately 15 million ha between 1990 and 2015 (FAO, 2015b). Some four million hectares of the current forest area are tree plantations, and 44% of the plantations are grown by smallholders with an average plantation size of 1.27 ha (MARD, 2016).

As already mentioned, absence of comprehensive, comparable and reliable statistics or maps on smallholder tree growing in the case-study countries does not allow a systematic numeric description and comparison of the outcome between years and countries. Instead, estimates on smallholder tree growing area were searched from available statistics, studies and other secondary sources to build understanding of tree growing trends and its strength. The scale measuring the outcome was set simply as weak-moderate-strong, with 'moderate' and 'strong' status considered as a positive outcome receiving value [1].

4.3.3. Analysis of necessity – necessary remote factors for smallholder commercial tree growing

As explained in Section *0*, the enabling environment in this study has factors (or conditions) that are classified into two groups: remote or proximate. Factors are described under Section 0 (*2.2.* Enabling factors). Land and forest tenure (TEN), demand and supply balance (DEMSUP), land use competition (from agriculture, AGR), and macroeconomic environment (MACRO) are classified as remote as shown in Table 4 (page 42). Proximate (i.e. sectoral) factors are capacity and knowledge in tree growing (KNOW), markets for smallholder grown wood (MAR), direct incentives (DIRINC), and indirect incentives (INDIRINC).

This section briefly describes the forest policy and incentive framework in the case-study countries, with the enabling factor evolution summarized in Table 18 below. Country matrixes contain the more detailed information on the factors that are used for factor coding, and are available via Mendeley Data (http://dx.doi.org/10.17632/nz252wbjyn.1). Each factor is given a value based on several indicators and a pre-set threshold, which are described in more detail in the matrixes.

Remote enabling factors (Table 17) have been either stable or improved in all case-study countries over the review period. All countries have introduced at least some policies promoting private and smallholder tree growing, but the extent of the policies, governing capacity, and financing to implement them vary between countries. Land tenure reforms have been implemented in all countries since 1990, and even in those countries where state land ownership prevails, land allocation, land tenure rights (incl. transfer rights) and their implementation are similar with actual private ownership rights. However, recognition of traditional/communal land rights is rather recent (e.g. in Indonesia and implementation of these rights is not yet clear, thus conflicts over land use have been and still are common).

Population growth is slowing down in Indonesia, Vietnam, and Laos, where urbanization is also rapid. But in Tanzania and Uganda the population growth has exceeded 3% throughout the review period, and the majority of their populations live in rural areas. Indonesia and Vietnam have significant export-oriented forest industry sectors and strong domestic demand, whereas in Tanzania and Uganda wood demand is domestic and industries are not yet capable to produce export-quality products. In Laos wood industries are very small-scale and most of the wood (from natural forest and plantations) is exported to China, Vietnam, and Thailand as logs or low-grade sawn wood. All countries except Vietnam are still experiencing net deforestation (in Laos the positive signals of reforestation are mainly due to increasing rubber plantation area).

Agricultural productivity has increased significantly in Vietnam, Indonesia, and Laos during the review period, and they are currently self-sufficient in rice. But in Tanzania and Uganda agricultural productivity is well below world averages, with productivity increase barely enough to feed the growing population (Lokina et al., 2011; MoFPED/UNPF, 2017). Vietnam, Laos, and Indonesia have experienced various cash crop booms, with an oil palm boom continuing to dominate Indonesian agricultural and forestry schemes. In Uganda and Tanzania cash crop booms have taken place (e.g. tea, coffee and cotton), but they have not reached the same scales as in the Asian case-study countries.

The countries included in the study are either low or middle-income countries, but what is common to all of them is the rapid economic development they have experienced in last 20-30 years. Political stability has also improved in all countries during the review period. Uganda has gone through a recovery

from the civil war, and in Indonesia the political regime changed after the resignation of the long-term president Suharto in 1998.

Table 17. Definitions of remote enabling factors for smallholder commercial tree growing

Contextual (Remote) factors		**Present (supportive for tree growing) if:**
Land and tree tenure	**TEN**	Land ownership is strong and respects individual tree growers' rights and allows for tree growing.
Demand and supply balance	**DEMSUP**	Strong domestic or/and export-oriented wood demand.
Agricultural pressure	**AGR**	Agricultural policy does not incentivize for land conversion to agriculture at the cost of forest/plantation, and/or incentivizes tree growing/forest management to provide environmental services for agriculture. Demographic patterns and agricultural technology development are decreasing pressure for more agricultural land.
Macroeconomic development and political stability	**MACRO**	The country is either classified as at least lower middle-income country and/or the annual GDP growth has been >5% for last 10 years. Political stability ranking (with the World Bank data) is ≥0 (scaling from -1 to +1).

Table 18. Contextual factors' evolution by country.

	Year	**Land and tree tenure (TEN)**	**Demand and supply balance (DEMSUP)**	**Agricultural pressure (AGR)**	**Macroeconomic development and political stability (MACRO)**	**Smallholder commercial tree growing area (OUTCOME)**
Laos (LAO)	1990	0	0	0	0	0
	1995	0	0	0	1	0
	2000	1	0	1	0	0
	2005	1	0	1	0	0
	2010	1	1	1	1	1
	2015	1	1	1	1	1
Tanzania (TNZ)	1990	0	1	0	0	0
	1995	0	1	0	0	0
	2000	0	1	0	0	0
	2005	1	1	0	0	1
	2010	1	1	0	1	1
	2015	1	1	0	0	1
Java (JAVA)	1990	1	1	0	0	1
	1995	1	1	1	1	1
	2000	1	1	1	0	1

	Year	Land and tree tenure (TEN)	Demand and supply balance (DEMSUP)	Agricultural pressure (AGR)	Macroeconomic development and political stability (MACRO)	Smallholder commercial tree growing area (OUTCOME)
	2005	1	1	1	0	1
	2010	1	1	1	0	1
	2015	1	1	1	0	1
Kalimantan & Sumatra (K&S)	1990	0	1	0	0	0
	1995	0	1	0	1	0
	2000	0	1	1	0	0
	2005	0	1	1	0	0
	2010	0	1	1	0	0
	2015	0	1	1	0	0
Uganda (UGA)	1990	0	1	0	0	0
	1995	0	1	0	0	0
	2000	0	1	0	0	0
	2005	1	1	0	0	1
	2010	1	1	0	0	1
	2015	1	1	0	0	1
Vietnam (VNM)	1990	1	1	1	1	1
	1995	1	1	1	1	1
	2000	1	1	1	1	1
	2005	1	1	1	1	1
	2010	1	1	1	1	1
	2015	1	1	1	1	1

Notes: '0' = enabling factor absent/smallholder tree growing area stagnant or decreasing; '1'= enabling factor present/smallholder tree growing area increasing. Abbreviations: LAO = Lao PDR; TNZ = Tanzania; K&S = Kalimantan and Sumatra; VNM = Vietnam; R = Remainder; C = Contradiction. The number after the country code indicates the reporting year.

The first step of the QCA included sensitivity analysis, which is available in Appendix 4. Ten (10) different combinations of contextual factors are observed out of the 16 possible combinations after the sensitivity analysis, thus leaving six (6) logical remainders (Table 20). Theoretically, all combinations can be considered possible, thus logical remainders are included in the analysis. Contradictory cases were not identified in this analysis. Figure 13 below illustrates the distribution of the configurations in the Venn diagram.

Consistency and coverage measure fitness of the identified formulas. Solution formula **TEN*DEMSUP** has full consistency; i.e. **TEN** (tenure) and **DEMSUP** (demand) are present in all cases with positive outcome 1 (increased tree growing). Coverage analysis is presented in Table 19. Strong consistency and good coverage support the acceptance of the solution formula, thus the **TEN*DEMSUP** is used as the basis for the second step of the two-step QCA analysing proximate factors.

Table 19. Coverage analysis of the remote conditions – Step 1

	Outcome [1]		**Outcome [0]**	
RAW COVERAGE the proportion of [1] outcome cases covered by	TEN [1]	20/36	TEN [1]	2/36
	DEMSUP [1]	20/36	DEMSUP [1]	12/36
UNIQUE COVERAGE the proportion of [1] outcome cases that are uniquely covered by a given term (no other terms cover those cases)	TEN [1]	0/36	TEN [1]	0/36
	DEMSUP [1]	0/36	DEMSUP [1]	7/36
SOLUTION COVERAGE the proportion of cases that are covered by all the terms	TEN*DEMSUP	20/36	TEN*DEMSUP	0/36

The final configuration (based on Graph-based Agent algorithm) includes two necessary (i.e. 'outcome enabling') factors.

TEN*DEMSUP

Upper-case letters denote presence of a factor and lower-case absence, thus according to the analysis strong tenure rights and strong demand for wood must be present. No simplyfying assumptions were made in the process of reduction.

Table 20. Final truth table of Step 1

CASEID	TEN	DEMSUP	AGR	MACRO	OUTCOME
LAO90	0	0	0	0	0
LAO95	0	0	0	1	0
TNZ90, TNZ95, TNZ00, K&S90, UGA90, UGA95, UGA00	0	1	0	0	0
K&S95	0	1	0	1	0
K&S00, K&S05, K&S10, K&S15	0	1	1	0	0
LAO00, LAO05	1	0	1	0	0
TNZ05, TNZ15, JAVA90, UGA05, UGA10, UGA15	1	1	0	0	1
TNZ10, VNM90, VNM95, VNM00, VNM05, VNM10, VNM15	1	1	0	1	1
JAVA00, JAVA05, JAVA10, JAVA15	1	1	1	0	1
LAO10, LAO15, JAVA95	1	1	1	1	1

Notes: '0' = enabling factor absent/smallholder tree growing area stagnant or decreasing; '1'= enabling factor present/smallholder tree growing area increasing. Abbreviations: LAO = Lao PDR; TNZ = Tanzania; K&S = Kalimantan and Sumatra; VNM = Vietnam; R = Remainder; C = Contradiction. The number after the country code indicates the reporting year.

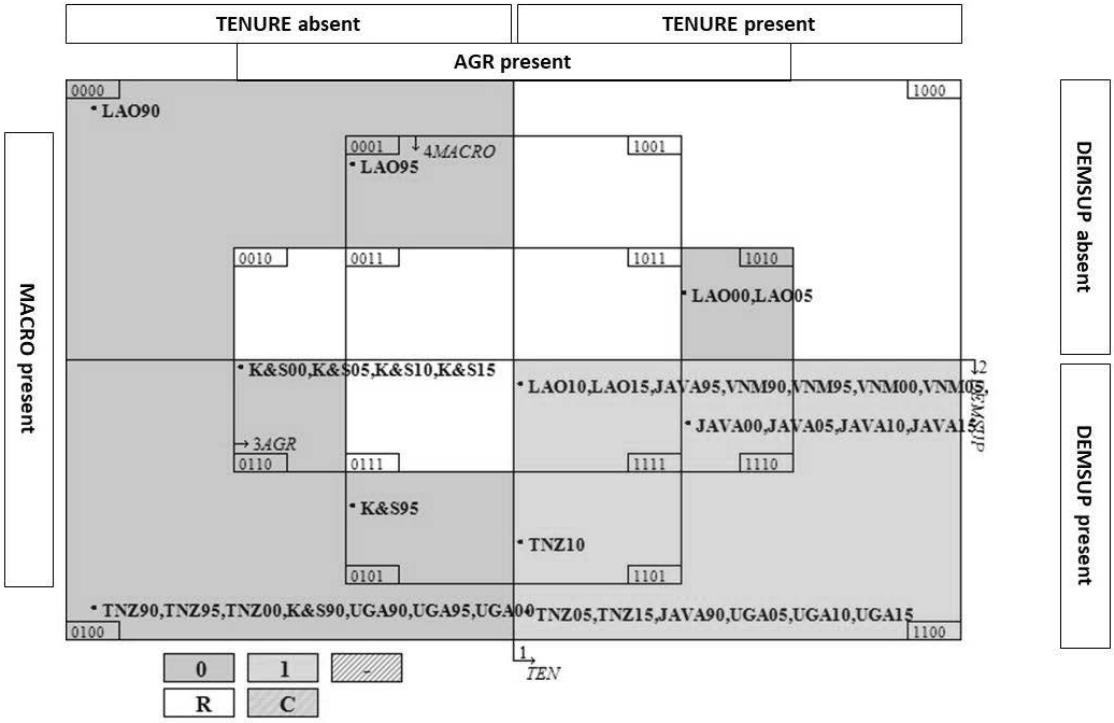

Figure 13. Visual presentation of configurations and logical remainders of the remote factors.

Green colour indicates positive outcome, pink negative. White areas are logical remainders with zero cases. Binary coding of the factors is presented in a corner of each configuration box.

4.3.4. Analysis of sufficiency – sufficient proximate factors and the role of incentives

The second step in the QCA analysis includes the cases included in the first step configurations and analyses the sufficient 'sectoral' conditions. The factors included in the analyses include wood markets and pricing (MAR), Capacity and knowledge (KNOW), Direct incentives (DIRINC) and Indirect incentives (INDIRINC). The factors are described in more detail in Table 21 below.

Table 21. Definitions of proximate factors

Sectoral (Proximate) factors		Present (supportive for tree growing) if:
Wood markets and pricing	**MAR**	Wood pricing is market based (not regulated) and smallholders have access to wood markets through a reasonably well working market mechanism.
Capacity and knowledge	**KNOW**	Smallholder tree growers have adequate tree growing knowledge, and/or access to financing and good quality extension services for tree growing.
Direct incentives	**DIRINC**	Forest policy is in place, and direct incentives are applied (seedling, grants etc. to tree growers, extension services, allocation of land for tree growing), and they significantly increase the attractiveness of tree growing for smallholders vs. other land uses.
Indirect incentives	**INDIRINC**	Forest policy is in place and identifies the indirect incentives, and they are applied (e.g. removal of bureaucratic barriers, research, market development, land tenure related benefits etc.). Indirect incentives have significantly improved operating environment for tree growing (e.g. services and training for tree growers, market development, etc.). Regulation and bureaucracy on smallholder tree growing is at reasonable level and its costs are modest vs. the expected profits from tree growing. If fees and licenses exist (but are not applied in reality) the regulative environment can also be considered supportive for smallholder tree growing.

Policy environment and tree growing incentives in 1990-2015

All five countries have developed and revised their forest policies at some point during the review period 1990-2015. The extent to which smallholder

tree growing is recognized in national forest policies, related laws and regulations, and how financing is allocated for functions or incentives supporting smallholder tree growing vary considerably between countries. The matrixes available in Mendeley Data (http://dx.doi.org/10.17632/nz252wbjyn.1) present the evolution of factors and their indicators that are the basis for the binary coding of factors as present [1] (i.e. supportive for smallholder commercial tree growing) or absent [0] (i.e. not supportive for tree growing).

Table 22. Proximate factors' evolution by country.

	Year	Wood markets and pricing (MAR)	Capacity and knowledge (KNOW)	Direct incentives (INC)	Indirect incentives (INDIRINC)	Smallholder commercial tree growing area (OUTCOME)
Lao PDR (LAO)	1990	0	0	0	0	0
	1995	0	0	0	0	0
	2000	1	0	0	0	0
	2005	1	0	0	0	0
	2010	1	0	0	0	1
	2015	1	0	0	0	1
Tanzania (TNZ)	1990	0	0	0	0	0
	1995	0	0	0	0	0
	2000	0	0	0	0	0
	2005	0	0	0	0	1
	2010	0	0	0	0	1
	2015	1	0	1	1	1
Java (JAVA)	1990	1	0	1	0	1
	1995	1	0	1	0	1
	2000	1	0	1	0	1
	2005	1	1	1	0	1
	2010	1	1	1	0	1
	2015	1	1	1	0	1
Kalimantan & Sumatra (K&S)	1990	0	0	1	0	0
	1995	0	0	1	0	0
	2000	0	0	1	0	0
	2005	0	1	1	0	0
	2010	0	1	1	0	0
	2015	0	1	1	0	0
Uganda (UGA)	1990	0	0	0	0	0
	1995	0	0	0	0	0
	2000	0	0	0	0	0
	2005	1	1	1	1	1
	2010	1	1	1	1	1

	2015	1	1	1	1	1
Vietnam (VNM)	1990	0	1	1	0	1
	1995	0	1	1	1	1
	2000	1	1	1	1	1
	2005	1	1	1	1	1
	2010	1	1	1	1	1
	2015	1	1	1	1	1

Notes: '0' = enabling factor absent/smallholder tree growing area stagnant or decreasing; '1'= enabling factor present/smallholder tree growing area increasing. Abbreviations: LAO = Lao PDR; TNZ = Tanzania; K&S = Kalimantan and Sumatra; VNM = Vietnam; R = Remainder; C = Contradiction. The number after the country code indicates the reporting year.

Indonesia has promoted forest industry and industrial forest plantations since the Suharto era in the 1990's (Obidzinski and Chaudhury, 2009). Smallholder tree growing also received support already in the 1970's through a so-called farm forestry programme that focused on tree growing on private lands, mainly in Java (Potter and Lee, 1998). A multitude of smallholder and community tree growing (and forest management) schemes have been introduced during the study period, with varying objectives, tools and incentives, and available resources (Kartodihardjo et al., 2013; Nawir et al., 2007; Obidzinski and Dermawan, 2010). Despite of the various support programmes and even incentives provided, only smallholder tree growing on private lands, so called *Hutan Rakyat,* has increased significantly during 1990-2015, mainly in Java where private land tenure prevails.

In Laos, forests' importance has been recognized by the government since the early 1980's, and policies have aimed to improve sustainable forest management, promote reforestation and afforestation, and to eradicate shifting cultivation (which the government sees as a major driver of deforestation and forest degradation). Vision 2020 published in 1997 set the target to restore the national forest cover to 70%. In the 1990's policy focus turned to sustainable forest management and restoration, preservation, and reforestation to retain the economic potential of forests through rationalization of land uses, agro-ecological zoning, and balancing development and conservation purposes on the basis of scientific assessments of soil erosion risks, ecological degradation and recovery rates. The aim was 'turning land into capital' to attract foreign investors to utilize lands that were considered degraded and under-utilized. (Lestrelin et al., 2012). In this context a legal framework was set to allocate smallholder farmers lands classified as degraded to bring them under productive use. This was supported with tax exemption incentives for forest

plantations, but the allocation and incentive procedures have remained bureaucratic and complex (Smith, 2016, 2014).

A Forestry Strategy 2020 for Lao PDR was released in 2005 and it includes a programme for plantation forestry promotion and development (Prime Minister's Office, 2005). The strategy recognises the bureaucratic complexities and weak supportive services in land allocation and smallholder plantation management, setting an objective to simplify regulation and build the knowledge and capacities in the extension network and to create additional incentives for smallholder tree growing. So far, evidence on delivering the strategy objectives has remained weak at the grassroots level (Smith and Alounsavath, 2015).

In Tanzania, the first (and still valid) forest policy prepared after independence is from 1998, while the new policy under preparation has been pending for years (United Republic of Tanzania (URT), 1998). The 1998 Policy and the Forest Act 2002 (Government of Tanzania, 2002) both aim to give private sector a larger role in managing Tanzanian forest resources, including forest plantations. However, the Act is silent on the smallholder plantations, which normally fall below the five (5) ha limit set for the application of the law. The policy sets a target for 'harmonized extensions services' and financial incentives to support private and community forestry. To date, however, the most significant legislative revision from the smallholder perspective is the Land Act introduced in 1999 (Government of Tanzania, 1999), which gave village-level authorities governance rights on lands classified as village lands. Gradually, after trust for these rights has grown, this secured smallholder land rights and has allowed them to enter, for example, the tree growing business. The extension services, especially for tree growing, remain undeveloped and under-resourced, and the financial incentives for smallholder tree growing have only been introduced since 2014 through donor-supported programs (Arvola et al., 2019).

Ugandan forest policies have gone through significant revisions during the 1990-2015 period. The forest policy 1988 focus was in natural forest management and gazetted forests. The government published a new policy in 2001 (Ministry of Water, 2001) and its implementation was further elaborated in the National Forest Plan published in 2002 (MWLE, 2002), both emphasizing the development of forest plantations, and particularly private forest plantations. The National Forest Plan introduced the Plantation Development Fund, which supports private plantation investments with

financial incentives, combined with revision of taxation, land rent, and licencing terms. Promotion and support are targeted to plantation investments of all sizes, but the Plan emphasizes the role of large-scale plantations in meeting future wood demands. Incentives for private plantation forestry have been provided through a specific EU financed Sawlog Production Grant Scheme (SPGS), which started operating in 2004 and is now initiating the third phase.

Vietnam initiated the economic reform programme 'Doi Moi' in 1986 with the aim to move towards a 'free market' economy, which ended nearly 30-years collectivization of agricultural lands in 1988. The First National Forest Policy introduced in 1991 signalled a move from state forests towards partial privatization of forest lands (De Jong et al., 2006). The government introduced several decisions and laws in 1992-1995 that allowed allocation of land to individual households and formalized their rights on these lands. A massive tree growing promotion programme 'The 5 Million Ha Reforestation Programme' started in 1998 and continued until 2010. Individual households and other private sector entities had a significant role in the campaign as they were responsible for planting some 2 million ha of the targeted area. To achieve this, they were supported with access to land, materials, technical support and cheap loans. Land tenure rights were further clarified in the early 2000's (Smith et al., 2017a). The Vietnam Forest Development Strategy 2006-2020 highlighted the role of the private sector in forestry and set a target to establish 1.0 million ha of new plantations by 2010, and 1.0 million ha for the following phase (Socialist Republic of Vietnam, 2007).

The case-study countries have large variation in incentives applied, with Vietnam and Tanzania being the two extremes on the scale. Vietnam has invested in and applied extensive direct and indirect incentives to promote and support smallholder commercial tree growing, whereas Tanzania has only recently introduced some direct, project-based incentives for smallholder tree growers.

Especially in Vietnam and Lao PDR, market liberalization has been significant during the study period, but wood markets have also moved from regulated and state-dominated wood trade towards an increasing private sector role in forestry and free wood markets in Uganda, Indonesia, and Tanzania. In all countries, smallholder tree growers rely on middlemen networks for wood sales. However, either domestic or imported (illegal) timber distorts wood pricing in most of the case-study countries, although natural forest (hard)wood

and plantation grown wood do not directly compete since they mostly serve different segments of wood industries and markets.

Extension services are available to varying extent and capacities, but in general, they are mainly sporadic, relying on project-based financing and focusing on tree plantation establishment, not so much on plantation management. Tree growers' organizations (associations) are either absent or only at early stages of development, and their development is supported with project based external (donor) funding with limited regional scope.

Second step of the two-step QCA protocol – analysis of sufficiency

The purpose of the second step in the two-step QCA is to identify which proximate factors must be combined with necessary remote factors to enable smallholder tree growing to evolve and develop. The analysis was carried out according to the updated two-step protocol (Schneider, 2018). The second step included those cases that were included in the configuration for the outcome (**TEN*DEMSUP**) in the first step.

The proximate factors in the Lao PDR case call for further analysis as the incentives - both direct and indirect – are open to interpretation. Sensitivity analysis was therefore taken to assess different interpretations of incentives in the Lao PDR, and is available in Appendix 4. The final truth table of the factors in the second step produced based on the sensitivity analysis is presented in Table 23 below.

The analysis applied the procedure for the most conservative solution (i.e. no assumption about any logical remainder is made because in theory, all combinations of the factors could be possible).

Table 23. Truth table for the necessary remote and sectoral (proximate) factors

Country-case ID	Remote factors	Proximate factors				
	TEN*DEMSUP	MAR	KNOW	DIRINC	INDIRINC	Outcome
TNZ05, TNZ10	1	0	0	0	0	1
NM90	1	0	1	1	0	1
VNM95	1	0	1	1	1	1
LAO10, LAO15	1	1	0	0	0	1
JAVA90, JAVA95, JAVA00	1	1	0	1	0	1
TNZ15	1	1	0	1	1	1
JAVA05, JAVA10, JAVA15	1	1	1	1	0	1
UGA05, UGA10, UGA15, VNM00, VNM05, VNM10, VNM15	1	1	1	1	1	1

Notes: '0' = enabling factor absent/smallholder tree growing area stagnant or decreasing; '1'= enabling factor present/smallholder tree growing area increasing. Abbreviations: LAO = Lao PDR; TNZ = Tanzania; K&S = Kalimantan and Sumatra; VNM = Vietnam; R = Remainder; C = Contradiction. The number after the country code indicates the reporting year.

The final configurations indicate that secure land and forest tenure, and strong demand may be sufficient to boost smallholder tree growing (configuration 3), but well-functioning wood markets or strong knowledge base combined with direct incentives play their role in many cases (configurations 1 and 2), as the Vietnamese and Uganda cases indicate. However, only secure tenure and strong enough demand has allowed smallholder tree growing area expansion in Lao PDR in 2005-2015, and in Tanzania in 2005-2010 in the absence of knowledge base, and feasible direct and indirect incentives. However, it should be noted that the scale or pace of area expansion has been lower compared to cases with more enabling factors present (in Vietnam, Indonesian Java, Uganda). In fact, the third configuration not only included tenure and demand, but it indicated that the absence of incentives, both direct and indirect, formed part of the configuration, as well as absence of capacity and knowledge base. Absence of indirect incentives in the third configuration could potentially be a consequence of smallholder tree growers operating in the informal sector, especially in Tanzania. Furthermore, supply chain actors for smallholder timber have found ways to circumvent regulations (e.g. in Laos where

bureaucracy is heavy)**.** However, the configuration should not be interpreted assuming that absence of knowledge, and direct and indirect incentives would have an increasing impact on smallholder commercial tree growing. Based on earlier research findings it is evident that these factors rather tend to increase tree growing interest (their impact is either zero or positive). Thus, in the third configuration their absence should be interpreted having neutral, not increasing impact.

Either markets or knowledge combined with direct incentives were present in two configurations representing the majority of the cases in the second step. In Tanzania 2005 and 2010, and Laos 2010 and 2015, only the necessary conditions (i.e. tenure and demand) were also sufficient for the expansion of smallholder tree growing – although the market mechanism was also present in Laos at that time. On the one hand this highlights the importance of these factors, but on the other hand this could be seen as an indication of smallholders' capacity to rationally diversify their livelihoods and grasp market opportunities without additional incentives. But only as long as the government does not set bureaucratic obstacles in the way or if these can be circumvented, which is often the case, for example in Indonesia and Lao PDR (Maryudi et al., 2017; Smith et al., 2017c).

The configuration **KNOW*DIRINC*TEN*DEMSUP** represents Vietnam, Java, and Uganda, where governments or specific projects have triggered tree growing by introducing tree growing models and provided initial resources and knowledge. The role of government has been crucial, particularly in Vietnam and Uganda (Maryudi et al., 2017; Ofoegbu and Babalola, 2015; Roshetko et al., 2013; Sikor and Baggio, 2014)

Knowledge building (including extension) has been supported with direct incentives, which has resulted in a remarkable expansion of commercial tree growing area in each of these countries/regions. It should, however, be noted that many of the cases in this configuration are also included in the configuration **MAR*DIRINC*TEN*DEMSUP,** so both markets and knowledge have been present together with the incentives**.** In general, extension services are not reaching individual smallholders, which is a combination of the scant extension resources and low level of organization among tree growers, even in the Vietnamese and Java cases (De Jong et al., 2006; Kallio et al., 2012; Permadi et al., 2017). Smallholders tend to grow commonly known – often exotic – tree species with reasonably short rotations and with some existing local experience in their growing (peer learning).

Smallholders are copying plantation management practices from large scale government or company plantations with varying success, while large plantations have also developed improved germplasm and nursery services (Howard et al., 2005; Tembani et al., 2014). It can be assumed that access to seeds and seedlings, knowledge on these species, and existing markets for these species drives their decision making on tree growing. Without significant extension (and incentives) input they are unlikely to easily alter their tree growing models as long as they are profitable (Harrison et al., 2008; Maraseni et al., 2017a). Reliance on a single species and limited number of provenances is a major risk for smallholder tree growing. It may be only a matter of time before Acacia plantations in Vietnam and pine plantations in Tanzania will be attacked by disease outbreaks similar to those that have already occurred in Indonesia, Malaysia, and South Africa (Irianto et al., 2006; Kanyi et al., 2005; Maraseni et al., 2017a). Tree grower organizations are one way to channel and produce knowledge and services for smallholders, but in most case-study countries they are established with external support and are not yet independently capable to provide their members with high quality advisory or technical services (Ling et al., 2018; Mafuru et al., 2018; Sessanga et al., 2018).

4.3.5. Role of incentives

This study highlights the importance of strong demand and land and tree tenure in allowing smallholder tree growing to evolve and recognizes the importance of direct incentives in two out of three configurations. The coverage analysis also shows that the configurations including direct incentives cover a substantially larger amount of cases compared to the configuration without direct incentives (Table 28).

Due to the binary nature of the outcome analysis and the crisp set method applied, the QCA analysis does not clearly differentiate the strength of the tree growing trend. Positive outcomes may include countries where smallholder commercial tree growing could even be classified as a ‘boom’ (Vietnam), countries where the pace of increasing tree growing area is very rapid even though the areas are not yet very large (Uganda), and cases where the trend is positive but area expansion and pace of the area increase can be considered only moderate (Laos).

It should be noted too that in Vietnam, Uganda, and Laos, land allocation (i.e. providing access to land for smallholders for tree growing) has been one of the key incentives allowing tree growing expansion in the first place. The number

of cases is small but gives some indication that even though direct incentives may not always be necessary (if land is available), they tend to accelerate the tree growing expansion.

4.4. Summary of the main findings

4.4.1. Smallholder tree growing in the Southern Highlands of Tanzania and farmers' interaction with and access to timber markets (Paper I)

Hypothesis: Despite the rapid tree growing area increase, smallholder tree growers in the Southern Highlands face challenges in accessing tree growing inputs, which limits their capacity to produce high quality wood and access to markets.

Research questions	Main findings
1.1 How do farmers in the Southern Highlands of Tanzania address and tackle the common problems of a smallholder tree grower, such as accessing planting materials, technical, and market knowledge?	*Outside of projects, smallholder tree growers in the Tanzanian Southern Highlands do not have access to high quality planting material * Extension services are not available outside of project support * Smallholder tree growers have negligible bargaining power in wood sales * Market information systems were recently launched under project support
1.2 How successful are farmers in the Southern Highlands of Tanzania in producing high quality wood?	* The quality of wood is low and the wood is sold prematurely * Farmers do not have skills nor capital to do professional forest plantation management * The high market demand allows smallholders to sell even juvenile, low quality wood
1.3 How do farmers in the Southern Highlands of Tanzania access the markets, and what are the prices paid for a smallholder tree grower versus the prices paid for timber from industrial plantations?	* Smallholder tree growers rely on trader/middlemen and informal networks to access the markets and market information. * Under high demand the prices received are good and in line with, or even higher than prices paid for wood from government/industrial plantations

4.4.2. Development of smallholder tree growing in Lao PDR against the policy, legal, socioeconomic and market background, and the role of supportive government policies (Paper II).

Hypothesis: Smallholders' interest in commercial teak growing is limited due to complexities in the regulatory environment, weak incentives, and competing land uses.

Research questions	Main findings
2.1 How has the political and legal environment recognized and supported smallholder teak growing over the years in Lao PDR?	* Smallholder tree growing has been promoted since the early 1990's in Lao PDR. The main incentive has been land allocation for tree growing. Other incentives (tax exemptions) have very little value for smallholders because heavy and costly bureaucratic procedures are necessary to benefit from the exemptions.
2.2 How have smallholder teak growers responded to the changes in the enabling environment for tree growing?	* Land allocation in early 1990's and land law revisions in early 2000's have induced tree growing in the study villages. * High demand for cash crops and quicker returns from them are now reducing interest in teak growing and tree growing area expansion. * Smallholders report land availability as a constraint for increasing tree growing, thus land allocation may no longer serve smallholders' needs. * Reducing natural forests and natural hard wood sources are reflected as an emerging interest in growing other valuable native hard woods.

4.4.3. Contextual and sectoral factors and their combinations that allow smallholder tree growing to emerge in the case-study countries.

Hypotheses: Sustained smallholder tree growing schemes can emerge with varying configurations; i.e. combinations of enabling factors as drivers for tree growing. Tree growing incentives are only effective if they target and alleviate/solve the key bottlenecks or missing factors in the enabling environment.

Research questions	Main findings
1. What are the necessary and/or sufficient conditions for sustained smallholder tree growing in the case-study countries?	* Secure land and forest tenure, and market demand are necessary conditions for smallholder commercial tree growing.
2. What is the role and success of incentives in promoting smallholder tree growing in varying enabling contexts?	* Smallholder commercial tree growing may develop and expand even without direct incentives, but direct incentives increase the smallholder commercial tree growing area. * In addition to necessary factors (tenure and demand), direct incentives and knowledge base/well-functioning markets contribute to tree growing area expansion. In Laos and Tanzania only tenure and demand have induced tree growing at some point, in the absence of direct and indirect incentives, or knowledge base.

5. Discussion

In this chapter the findings of this study are first discussed through the lenses of each enabling factor as presented in Figure 3, and the discussion also attempts to reflect the contribution of each factor considering the stages of forest plantation sector development in the countries included in this study (Figure 2). Sections 5.1 and 5.2 discuss the proximate and remote enabling factors and Section 5.3 draws the enabling factors together and discusses the identified pathways to smallholder tree growing, and how the findings could be utilized and generalized at the global level. Finally, the last paragraph (5.4) discusses the limitations of the study.

5.1. Proximate enabling factors

5.1.1. Markets for smallholder grown wood

In many developing countries smallholder tree growers face complicated regulatory requirements and administrative procedures in growing and selling trees, at least in the formal or export markets (Enters et al., 2006; Maryudi et al., 2015; Mejia et al., 2015; Smith et al., 2017c; Snelder and Lasco, 2008). The in-depth country case-studies and smallholder interviews conducted in this study indicated that they are not present everywhere, and may not be a major constraint for smallholders. In Tanzania smallholder woodlots are excluded from the red tape and the licensed processors and wood traders carry the administrative burden after the wood sales. This is one reason why the interviewed tree growers do not consider access to markets as a constraint, a finding that is contrary to the findings of Kulindwa's recent study (2016). In Lao PDR the regulation on tree growing is heavy, but smallholder tree growers either ignore or circumvent many of the regulations with the support of the middlemen who play a key role in helping tree growers to cope with the authorities.

Even though the wood markets and trading mechanisms are imperfect, they seem to have evolved along with the expansion of smallholder tree growing area, and smallholders do not consider access to markets as a constraint for tree growing. Smallholder reliance on middlemen and traders in woodsales is a global phenomenon that has remained the standard procedure among smallholders even in the era of emerging mobile technologies and services (Byron, 2001; Castrén et al., 2014; Matthies and Karimov, 2014; Mejia et al., 2015; Phi et al., 2004). Despite the growing volumes of smallholder wood, the market mechanims remain underdeveloped, and smallholders rely on local, incidental market contacts. The in-depth country case-studies (Papers I and II)

demonstrated that smallholders' knowledge on prices and market requirements are mainly weak or absent, and often non-existent alternative market channels leave them in a weak bargaining position. This is a finding of various studies in agricultural and forestry smallholder value chains (Boulay et al., 2013; Sikor, 2012).

However, based on the findings of this study, dependence on middlemen or limited access to marketing channels does not necessarily lead to lower prices for smallholder wood producers in a high demand situations, as the Tanzanian case-study demonstrated. In Tanzania prices paid for smallholders were in line with the governmental plantation wood prices, which also creates an additional challenge for extension programmes. Efforts to improve tree plantation management and wood quality are undermined by the over-demand in the wood market. Boulay et al. (2013) have similar finding of smallholder eucalyptus growing in Thailand, where the price paid to any actor is the same during high demand.

Wood markets in developing countries often lack any recognized formal grading standards, thus failing to give clear signals to wood producers of the linkage between wood quality and price paid for it. Findings both from Tanzania and Lao PDR indicate that smallholder producers serving growing timber markets are not necessarily aware of the diameter-price dependence or grading categories applied (Anttila, 2016; Midgley and Mounlamai, 2015), and they end up losing significant value by selling young stands. This in turn reduces the comparative advantage of tree growing against other land uses. However, from the smallholder perspective the increasing risks associated with the longer rotation and tree plantations role as a household 'savings account' favours shorter rotation compared to industrial plantations (Frey et al., 2018; Putzel et al., 2012). Developing grading standards and increased tree growers' awareness about them is often suggested as a means to improve productivity and profitability of improved plantation management (Moore et al., 2016; Perdana et al., 2012; Rohadi et al., 2012; Zziwa et al., 2009). However, when even smallholders' awareness of diameter and price dependence is weak, the system as such would not solve the problem from the smallholder perspective without substantial improvements in information and extensions services.

Figure 14. Matembwe Village in the Southern Highlands of Tanzania has become a local timber trade centre.

In this study, the quality of the wood the smallholders produce was assessed only visually (Tanzania) and via key informant interviews (Laos), but the assessment indicated that in the study areas and countries smallholder tree growers are not very conscious of the wood quality aspects, nor understand how management affects quality and price. In addition to the organizational and logistical challenges related to scale (i.e. smallholders are only able to produce small volumes), also the quality of the wood they produce does not necessarily meet the industrial standards. An exception among the countries included in this study is Vietnam, where smallholders mainly produce wood for chipping, thus wood quality is not as serious limitation as in Tanzania, Laos, and even in Indonesia where smallholders sell their timber mainly for micro and small sawmillers and furniture industries (Kallio and Kanninen, 2013; Roda et al., 2007; Roshetko et al., 2012). In general, low interest in management and quality may be a result of mismatched interests, with smallholder tree growers aiming for minimal investment in terms of money and time (as they prefer to allocate their resources to other livelihood activities). Therefore, the situation is not likely to change as long as the industry is not signalling clearly their quality preferences and rewarding for

more intensive management to achieve better wood quality (Kallio et al., 2011; Perdana et al., 2012).

Figure 15. Acacia woodlots grown for pulpwood in Vietnam are dense and their management intensity is low.

5.1.2. Capacity and knowledge in tree growing

A lack of technical skills and advisory services in tree growing often leads to low quality of the produced wood, which is one of the impediments for smallholder commercial tree growing and access to higher value markets (Macqueen et al., 2014). Smallholder tree growers all over the developing world face the challenge of accessing technical inputs for tree growing, including good quality planting materials (Gregorio et al., 2015; Harrison et al., 2008). In both in-depth country case-studies (Papers I and II) smallholder producers had relied mainly on locally produced seed and seedlings. Nevertheless, their perceptions on ease of access to the materials differed, as contrary to their Lao peers, Tanzanian smallholders listed their poor access to seedlings and the seedling quality as problems faced in tree growing. There are several potential explanations for this: teak growing has a long history in Lao

PDR, especially in Luang Prabang region, teak stumps used for planting are easy to produce and Lao producers did not recognize the potential of using improved seedling material. Whereas in Tanzania, tree (pine) growing is a fairly new livelihood activity for smallholders, and many of the tree growers had been influenced by the PFP extension services which raised awareness about the importance of high quality seedlings.

In forestry policies promoting smallholder tree growing the policy objectives and their indicators emphasize the tree growing area increase, the number of trees planted, or volumes of timber produced, leaving the quality and capacity aspects neglected (Pokorny et al., 2010).

Figure 16. Female forest plantation owners in Matembwe Village in the Southern Highlands of Tanzania have gained access to extension services.

Figure 17. A teak grower in Phialat Village in Lao PDR in his plantation. Weeding and pruning are common practices in smallholder teak stands but thinning is not practiced.

5.1.3. Tree growing incentives

Smallholder landowners value incentives and they can significantly alter the profitability of land uses (Osei et al., 2018). The results of this study indicate that incentives may have a significant effect, but their analysis is also complicated because of the nexus between access to land and direct incentives. The linkage is particularly strong in Vietnam where government land incentives were a prerequisite for tree growing, combined with access to credit and knowledge. In Uganda, provision of financial incentives has clearly been the tipping point for smallholder commercial tree growing, but an additional incentive through access to government land reserves for tree growing has allowed the tree growing expansion under limited private land availability. (Kaboggoza, 2011; Nel, 2015; Ofoegbu and Babalola, 2015). Lao PDR also applies the land allocation incentive, but it has not worked as efficiently as in Vietnam due to its bureaucratic complications and limitations from the smallholder perspective. In Indonesia, their role is not quite as evident: although many tree growers receive incentives, for example in Kallio's studies

only a few (2–10%) report incentives as significant in their decision-making concerning tree growing (2012; 2011).

Combinations of enabling factors (i.e. configurations) including incentives, identified in Paper III, covered 70% of the cases in the second step of the analysis, but indirect incentives were insignificant. The change induced with incentives is particularly noticeable in Uganda, where tree growing began developing after the introduction of a grant scheme under the Sawlog Production Grant Scheme (SPGS) in 2004. The significance of direct incentives is lessening in Java and Vietnam, as commercial tree growing has become a viable and attractive business (Kallio et al., 2011; Maraseni et al., 2017a). Previous research (Bull et al., 2006b; Enters et al., 2004) highlights the importance of indirect incentives at later stages of plantation sector development, so their absence from the configurations in the analysis may be due to the rather short history of tree growing in the case-study countries, or it may also reflect the governments' low law enforcement capacities, in which case improving the regulative environment, for example, has no influence as an indirect incentive, or the supply chain actors' may be capable to circumvent bureaucratic obstacles. Based on the findings of this study, we suggest that indirect incentives may be more significant for industrial scale operators and thereby also potentially affecting the demand for smallholder grown wood.

Incentive schemes targeting smallholder tree growing may fail or underperform due to a mismatch between the incentives and the interests, perceptions, needs and capacities of smallholders, or due to a failure to address the actual bottlenecks in the enabling environment for smallholder tree growing. For example, in Indonesia and the Philippines, schemes for smallholder support have not succeeded as expected mainly due to the heavy bureaucracy required to access the funds, and/or heavy bureaucratic requirements in tree plantation management and harvesting (Le et al., 2014; Noordwijk et al., 2007).

The long-term perspective of tree growing can easily make it a low priority for policy makers, as investments in the sector are not politically rewarding (Cooksey, 2012). In this light it is not surprising that the socialist market economies of Vietnam and China have been more successful in supportive policies and introducing incentive schemes, which eventually have led to creation of a significant smallholder tree plantation sector. In the African continent the governments are tempted to prioritize sectors that provide voters with concrete, short term benefits, in the context of budget constraints to

prioritize sectors such as health, education, infrastructure and agriculture, leaving the forestry sector often dependent on donor support.

Although land conflicts are mostly associated with large scale industrial plantations, elite capture takes place in the context of smallholder tree growing as well, for example in land allocation processes (Kröger, 2014; Sikor, 2012). The structure of this study did not directly address the issues of exclusion or elite capture, but the socioeconomic differences within case-study villages, especially in terms of access to land, suggest that such capture may have taken place. Although tree growing is a significant income source for many smallholders (Kallio and Kanninen, 2013; Matthies and Karimov, 2014), it is generally not an accessible or feasible livelihood option for the most disadvantaged groups (Sikor and Nguyen, 2007).

Presently, smallholder tree growing often focuses on wood production, with limited examples of integrating payments for environmental services (PES), climate change mitigation and adaptation with tree growing , although Vietnam has recently started to develop PES schemes and models also including planted forests (Pham et al., 2013). However, carbon payment schemes remain too complicated for smallholder tree growers to meet their requirements, and carbon prices are too low to cover the associated costs. Similar problems have afflicted forest certification schemes from the smallholder producer perspective (Maraseni et al., 2017b).

Even though results in Paper III suggest that indirect incentives are unnecessary and absent in increasing smallholder tree growing area, the question arises whether the scale could be completely different in Lao PDR with stronger indirect incentives? i.e. less complicated legal framework for smallholder tree growing and trade allowing the forest industries sector as a whole to develop and the demand for smallholder wood to increase.

5.2. Remote enabling factors

5.2.1. Land tenure

The critical role of tenure as a necessary condition for tree growing is not surprising in light of earlier research and experiences from practitioners (see for example Nawir et al., 2007; Sandewall et al., 2010b; Simmons et al., 2002). Clear and strong land tenure rights are identified as a precondition for any investment in land, and particularly for a long-term investment such as tree growing (Cronkleton et al., 2017; Deininger, 2013; Deininger and Jin, 2006; Mekonnen, 2009; Rahman et al., 2017; Rudel and Hernandez, 2017).

Furthermore, it is identified as being a key enabling factor in the forest transition process in Asia (Youn et al., 2017). In developing country contexts land tenure is linked to access to land, as land resources are largely governed by the state and smallholders have limited access to additional land. Customary land tenure is increasingly recognized in national land legislation and regulation, but land concession allocations and resettlement programmes have, for example, undermined customary land tenure systems, especially in the past decades (Lund, 2011; Sungusia and Lund, 2016; Wardojo and Masripatin, 2002).

Clear tenure rights at the local level, recognized and respected but without formalization in a cadastre system, are often enough for smallholder investments in land (Bugri, 2008; Ubink, Janine et al., 2009), with formalized rights not necessarily having an impact on land productivity (Sitko et al., 2014). However, formalized land tenure rights and titles are proposed to improve smallholders' access to financial services, as titled land could be used as a collateral. But some research evidence suggests that smallholders may consider the risk of losing such land too high (Ubink, Janine et al., 2009).

During the period under review in this study (1990-2015), all case-study countries/regions - except Kalimantan and Sumatra - have been able to establish land tenure systems that provide smallholders security over the land they manage for tree growing, with the associated smallholder commercial tree growing areas increasing at some point during the review period. However, tenure rights do not ensure access to land, which was found to be a limiting factor for tree growing in Tanzania and Lao PDR, and has been discussed by Sandewall et al. (2015), for example.

Urbanization may change this picture as the absentee landowners are looking for ways to maintain and secure their land rights, something which in Lao PDR, for example, is now often arranged by planting trees or renting the land to relatives. Land scarcity, combined with the foreseen impacts of climate change and climate refugee movements, may also increase insecurity and conflicts over land, and therefore the importance of formalized tenure systems.

Liu et al. and Youn et al. (2017; 2017) have studied forest transition processes in Asia including the role of government policies and smallholder tree growing in the transition process, and Rudel (2009) studied more specifically plantation expansion and smallholders' role in the process. These studies indicate that secure private tenure and strong promotional government policies are significant for forest transition to take place, similarly as for smallholder

commercial tree growing. For example, the Chinese and Vietnamese governments had - and still have - a central role in creating a 'push effect' for smallholder tree growing, and establishing the enabling environment by instituting solid tenure rights and ensuring access to land. Land access has indeed been one of the strongest incentive's governments have used in promoting tree growing in, for example, Vietnam, Laos, and to some extent in Uganda.

However, it should be kept in mind that the five countries and six regions in this study have their own specific features in smallholder land tenure, with a mix of colonial heritage, history of socialist systems, and an under layer of customary communal land tenure systems (Brent et al., 2018; de Jong et al., 2016; Pacheco, 2012). Cases from South and Central America could possibly change the balance and importance of necessary and sufficient factors as the land use and tenure history in the continent differ from the countries included in this study.

5.2.2. Demand and supply

The significance of wood demand as a trigger for smallholder tree growing was clear in the case studies from Tanzania and Lao PDR, and the QCA identified demand as a necessary factor for commercial smallholder tree growing in line with the findings of others, for example Godoy (1992), Meyfroidt and Lambin (2008), Raghavan and Shrimali (2015), Rudel et al. (2005), and Xu and Hyde (2019). Demand may have been an increase of a 'traditional' demand, which is the case among teak growers in Lao PDR, or smallholders supplying the furniture industry in Java. In Vietnam, Tanzania, and Uganda the demand is created by new industries and products for new tree species, and by the need to find substitutes for wood from declining natural forest resources.

In the Global South, wood for export-oriented processing and industries is still mainly sourced from large industrial scale plantations (Barua and Lehtonen, 2012; Jürgensen et al., 2014; Pokorny et al., 2010), with the exception of a few countries such as Vietnam (Nambiar et al., 2015; Nguyen et al., 2018) and to some extent South Africa (Howard et al., 2005; Lyons and Westoby, 2014). In Vietnam, government led smallholder tree growing schemes, and in South Africa, out-grower schemes established by forest industry companies, have created a smallholder tree growing sector large enough to supply pulp industries. Forest industries and forest plantation development could be called a 'chicken or egg' dilemma: forest industry development requires a reliable

source of wood that meets their quality and volume needs (Hoffmann et al., 2018), but tree growing for industrial purposes only emerges if there are industries in place. Therefore, policies promoting tree plantations and smallholder tree growing are often bound together with forest industry promotion policies, and the status of forest industries' operational environment indirectly influences the enabling environment for smallholder tree growing as well (Cossalter and Pye-Smith, 2003). In both cases illegal logging from natural forests, or illegally imported wood, may distort markets (EU-FLEGT Facility, 2014; Wells and Wall, 2005).

The mere presence of tenure and demand may be sufficient to spur tree growing (e.g. in Tanzania), where the government has followed 'a laissez faire–approach' for smallholder tree growing in village lands. Another example of such 'self-initiated' tree growing boom is Eucalyptus in Ethiopia, where policy-makers discourage Eucalyptus growing, but smallholders expand their tree growing due to high demand and profits (Jenbere et al., 2012). However, tree growing incentives have been introduced in Tanzania since 2014 by projects, thus the questions is, would the smallholder tree growing have become sustained without the incentives now being developed, or will it do so with the support of the incentives?

Demand (and price) fluctuations are not as critical in tree growing as they are in agriculture and with annual crops, but the proximate factor of capacity and knowledge may have an indirect impact on the long term demand for smallholder grown wood. In the medium and long term, quality problems originating from deficient management practices and a tendency to sell juvenile wood may risk the future demand for smallholder grown wood. The market is likely to become more selective, and substitutes may replace (poor quality) timber, for example as construction material (Indufor, 2011), or with cheaper alternatives such as plastics. Grading systems have been introduced in Indonesia, for example, to overcome quality problems, but according to Perdana et al. (2012) smallholders have a poor understanding of these systems, which in combination with the heavy bureaucracy leads to low profitability, and reduces smallholders interest to invest in plantation management.

Another key challenge is that smallholders often perceive their knowledge in tree growing and management to be good and sufficient, thus changing their practices to produce wood to better meet the market and industrial requirements would require highly improved extension services and strong awareness raising campaigns.

The tree growing trend continues strong in cases that have well-established tenure rights and forest industries such as Indonesian Java and Vietnam, where demand originates from both domestic and export-oriented wood industries (Nambiar et al., 2015; Roda et al., 2007; Roshetko et al., 2012). Even though demographic, trade, and global mega trends are behind wood demand, governments may take a role in establishing demand for smallholder-grown wood, as the Vietnamese government has done. In Vietnam, the role of strong promotional policies and land allocation created a 'push effect' and induced tree growing before the demand and markets were developed (Meyfroidt and Lambin, 2008; Sikor, 2006, 2001), but policy measures targeted for industry development were apparently timed accordingly (Smith et al., 2017a) and industrial demand was quickly established. In Tanzania, regulations increasing timber prices for government plantation wood (2007) seems to have added weight to the expansion of smallholder tree growing, but whether the domestic forest industries remain competitive and viable is also an open question.

In Tanzania and Uganda, demand originates from industries serving primarily domestic markets (EU-FLEGT Facility, 2014; Held et al., 2017; Indufor, 2011). In light of the massive wood exports from Laos to Vietnam throughout the last decades (Saunders, 2014; Smirnov, 2015) and increasing wood exports to China, it is surprising how little this is reflected in smallholders' tree growing interests. Three potential explanations are behind this: 1) illegal logging has distorted the markets and market prices, 2) smallholders have limited access to land, and 3) they prefer cash crops to trees, which are also in high demand in China (Delang et al., 2013; Friis and Nielsen, 2016; Guttal, 2011; Vongvisouk et al., 2016). In the 1990s and early 2000s, Lao PDR introduced similar land allocation incentives as Vietnam, but the promoted tree growing models were mainly different, some enabling factors were absent, implementation of the incentive was poor, and domestic forest industries were small, thus making the incentive ineffective in Laos compared to Vietnam. Although tree growers in Laos are apparently now confident enough of their land rights to establish and maintain small plantations/woodlots even without formal tree plantation registration (Smith, 2014), they have no access to additional land for tree growing with the current land allocation and leasing terms, and without capital to buy more land. However, absentee land holders, who maintain their title over the land by growing trees, are a group that may be increasing the tree growing area in Laos due to the urbanization trend (Cramb et al., 2015).

5.2.3. Land use competition

Agricultural intensification gives smallholders more options for their land use whereby after ensuring food security, smallholders aim to optimize their land uses considering their available land and labour force, knowledge of different crops, prices of different cash crops, and available incentives (Ebanyat et al., 2010; Lambin and Meyfroidt, 2010; Schreinemachers and Berger, 2006). Vietnam and Indonesia have taken a major leap in terms of agricultural productivity during the last three decades. Lao PDR has also been able to significantly increase agricultural productivity since the early 1990's. Furthermore, population growth has reduced from the 2-3% in the early 1990's to 1-1.5% in 2015, and urbanization has been rapid. Despite this, only Vietnam has been able to turn their trend of decreasing forest cover into an increasing trend so far (Lambin and Meyfroidt, 2010). Part of the explanation may be the double-edged sword of agricultural productivity. If the demand for agricultural produce is growing, increased profits from agriculture may lead to increased interest to utilize the land (and even clear more land for agriculture) for cash crop production. Potentially this may happen due to the strong Chinese influence in South East Asia (especially Lao PDR) and is already to some extent visible in the answers the smallholders gave in the interviews (Paper II). Similarly, in Indonesia (Sumatra and Borneo) the palm oil business has led to continuing forest cover loss and is often the preferred land use option for smallholder producers (Rist et al., 2010).

The picture is completely different in Eastern Africa where the agricultural productivity increase has been barely enough to feed the growing population, and the population growth rates remain close to or above 3%, leading to enormous pressure for more agricultural land. In this light, the enthusiasm of the smallholders to engage in tree growing and allocate land for that purpose is surprising – especially in Uganda where population growth has not shown any signals of decreasing and remains as high as 3.5% (2015).

Land use competition was not included as a factor in this study's analysis for increasing smallholder tree growing area, even though it is often referred to in forest transition models (Angelsen, 2007). The reason behind this could be the major differences in the socioeconomic factors and indicators used to describe the land use competition in the study countries. It should be also noted that, for example in Tanzania, regional differences are large due to varying population pressure and climatic and soil conditions in different ecoregions. On the other hand, even under the land use pressures, smallholder farmers have recognized

the potential of tree growing in diversifying their livelihood options and accumulating capital.

Climate change is already having, and is foreseen to have even more impacts on agricultural systems globally in the future. These changes, combined with the population growth will put enormous pressure on land resources, especially in Sub-Saharan Africa (Thornton et al., 2010; Ward et al., 2014). Therefore, in the future, monocultures may no longer be a feasible tree growing model for smallholder farmers, with systems needing to be diversified and turned to agroforestry systems to allow tree growing to continue while creating more climate resilient agricultural systems.

5.2.4. Macroeconomic environment

In this study 'macroeconomic environment' consists of political stability and economic growth. The significance and impact mechanism of the macroeconomic environment are different for large scale forest industries and forest plantations compared to smallholder farmers, particularly in developing countries. As this study has also demonstrated, in many cases smallholder landowners have their livelihoods outside the formal economy, yet economic growth and a stable political environment establish the basis for domestic demand and confidence needed to take the risk of a long-term investment in tree growing. The 'macroeconomic environment' factor did not come up as a necessary nor sufficient factor for smallholder tree growing in the QCA analysis, however, economic growth is behind the increasing purchasing power and growing demand for wood products, thus these two factors are interlinked (Jong-A-Pin, 2009). Also, in times of extreme political instability, such as the civil war in Uganda, land tenure systems are not trustworthy (Okuku, 2006), and land tenure may be cause for political instability (Svensson, 1998), thus these two factors are not fully independent either.

The significance of the macroeconomic environment may not be visible directly from the smallholder perspective, but indirectly the favourable business environment for forest investors and industries has an impact on wood markets and potentially those for smallholder grown wood as well.

Any larger scale forestry and wood industry investment requires a relatively stable and predictable political environment (Kanieski da Silva et al., 2017). For example, several forest industry companies have been screening Africa for their investments but so far very few have advanced in their operations, largely due to insecurities of the operational environment that are often linked to the

land use and concessions, and their social license to operate (Malkamäki et al., 2018).

5.3. Pathways to smallholder commercial tree growing

Two factors, secure tenure and demand for smallholder grown wood, are essential in paving the way for smallholder plantation area expansion. This study identified three configurations, or pathways: land tenure and demand alone, tenure and demand in combination with incentives and markets for smallholder wood, or with strong knowledge and capacity supporting smallholders. Even though the role of other factors was not critical in this study, generally speaking the number of enabling factors present has increased in all case-study countries over the years, and was higher in those countries/regions where the smallholder tree growing was the most established (Vietnam, Java).

Access to land and its secure tenure is a critical, necessary factor in enabling smallholder tree growing. Therefore, enabling policies and incentives providing access to land and/or securing land rights have contributed to increasing the smallholder tree growing area, combined with commercial demand for smallholder produced wood. Improving the knowledge base in smallholder tree growing, for example via extension services, contributes in most cases to the smallholder tree growing area expansion. The findings indicate that the role of indirect incentives' is not significant in enabling smallholder tree growing area expansion, possibly because smallholder tree growers mostly operate in the informal economy.

The two-level approach used in this study served well in building understanding on smallholder landowners' responses to the changes in the enabling environment for tree growing. The in-depth country case studies with interviews provided insights to the smallholder preferences and realities, their integration into the wood markets, and what has been the role and effectiveness of tree growing incentives in their decision making on land uses. The higher-level qualitative comparative study demonstrated how the individual level preferences and drivers trigger sectoral changes at the country level. Through the QCA, this study was able to identify critical factors composing the pathways to increasing smallholder tree growing.

Even though exact identifiable boundaries for plantation sector development stages presented in Figure 2 do not exist, this study considers Tanzania and Uganda as countries at the 'initiation stage' of their tree plantation sector. Indonesia has the longest history of tree plantation development and developed forest industries, therefore it is considered to be at an early 'maturation stage', although regional differences between islands are significant both in terms of

tree growing scale and types of forest industries present. Vietnam and Laos introduced their forest plantation promotional policies in early 1990's and since then, Vietnam has reached the 'acceleration stage', but Lao PDR seems to be stagnated in the 'initiation stage'. The significance of incentives is indeed declining in Vietnam (Dinh et al., 2017; Nambiar et al., 2015)and Indonesia (M H Kallio et al., 2011), where tree growing has become an established livelihood activity for smallholders.

With the support of previous research findings, the necessary enabling factors (i.e. tenure and demand) could be generalized at the global-level as critical factors for smallholder commercial tree growing to emerge, and should be considered as key factors in political decision making regarding smallholder tree growing in countries where that is on the political agenda. However, supporting policies and programmes for smallholder tree growing so far have emphasized the increase in planted area as the expected outcome, failing to address the management and quality issues, which leaves the smallholder producers in a weak position in supply chains for timber.

This study only included countries from South-East Asia and Eastern Africa, and therefore caution should be exercised in generalizing the findings to differing socioeconomic contexts. For example, land tenure systems in Latin America generally differ significantly from the countries included in this study, and further research with a larger number of countries included from all continents would be necessary to test and formulate truly global models. Also, findings provide a very general overview of culmination points on the smallholder tree growing path, and more in-depth research or, for example, other QCA methods should be applied to a wider selection of countries to understand the 'triggering points' better.

5.4. Limitations of the study

Both Tanzanian and Lao PDR case studies have a limited regional scope, thus the findings cannot be directly generalized at the national level. Field work methods in Tanzania and Lao PDR include subjective elements, such as socioeconomic ranking, and the sample size is small, thus the statistical representativeness of the interviews is limited. Use of the local forest extensionist as the field research assistant had both benefits and disadvantages: local knowledge allowed cross-checking of information in situ and easy formulation of clarifying questions, but it contains a risk that interviewees may not have been willing to share correct information (for example on their

income). However, observations during the interview do not support this, and middlemen were, for example, very open in the interviews.

An interesting phenomenon that this study could not assess is the increasing number of absentee landowners in Laos, although the level of urbanization was included as an indicator for land use pressure. Absentee landowners are reported to represent a large share of teak growers (Cramb et al., 2015; Smith et al., 2017a) as they plant teak to maintain their title and productive use of their lands. In addition, some individuals in Luang Prabang Province nearby the urban centre mentioned that they make better living by working as paid labour in restaurants or in construction work and therefore prefer to plant trees on their land, which do not require intensive management. Hence, it is possible that the urbanization and structural changes in Lao PDR will further strengthen this phenomenon.

Triangulation of the desk study findings with primary data based on field research was only possible in Tanzania and Lao PDR, while data from Indonesia, Uganda, and Vietnam is collected only through secondary sources. However, collaboration with acknowledged country experts in collecting and reviewing the data matrixes should have reduced the risks of subjective biases.

This study could only differentiate the market for smallholder grown wood in the in-depth case studies of Tanzania and Lao PDR, whereas the assessment of the market for the QCA study was at a general level. This study compared short and medium-long rotation tree growing schemes within the same framework. Accuracy of this type of research would benefit if the wood production models, especially the rotation, would be more similar, separating short and long rotation species.

Two-step QCA with crisp-set was chosen as the QCA methodology based on its applicability to the research question and the relatively small sample size. The factors and their framing simplify reality: as the Vietnam, Lao PDR, and Uganda cases demonstrate, factors are also interlinked. In these countries, access to land and tenure rights has also been used as an incentive. The complex regulative environment (i.e. absent indirect incentives) in Laos has negated the intended effects of other direct incentives such as tax exemptions. Although defining the indicator and factor thresholds is based on thorough country knowledge and is conducted with care, the judgements made may be challenged. Also, the outcome is presented only as ‘present’ or ‘absent’, even though variation occurs in the volume of tree growing. Furthermore, the

threshold setting for the scale of tree growing is based on expert assessment in the absence of reliable statistics or maps.

Consistent data and statistics of the indicators contributing to the factors are available for only a few indicators (MACRO, partly AGR) and therefore the data are collected from various, often secondary sources. Sources and their availability vary between the case-study countries. Thus, in-depth country-specific knowledge plays a significant role in the study, but may also reduce data objectivity and limits its interpretation.

Nuances and, for example, regional differences within certain case countries are lost in the generalization of the indicators into factors. For example, markets have been analyzed at the general level and this study could not address market features such as price sensitivity, wood and agricultural crop price fluctuations and their possible influence on tree growing trends, and regional differences in them.

6. Conclusions and recommendations

Challenges that smallholder tree growers face are reported in many previous studies and have not changed much over the years. Therefore, it is astonishing how little attention and efforts are truly made to improve the enabling environment for smallholder tree growing, and on the other hand, to improve their performance as smallholder landowners effectively respond to the enabling environment factors. Necessary enabling factors are secure land and tree tenure, and demand for smallholder grown wood, and these two factors may only sometimes enable increasing smallholder tree growing, but they are necessary at all stages of smallholder tree growing sector development. However, in most of the identified pathways to increasing smallholder tree growing, direct incentives have been applied, and/or general capacity and knowledge building in smallholder tree growing has contributed to the increasing smallholder tree growing. Direct incentives can be effective in the initiation and acceleration stages of smallholder tree growing, but their significance seems to decrease as the smallholder tree growing becomes established and reaches maturation stage.

The country case studies indicate that tree growing is a livelihood option helping smallholder farmers to diversify their income sources and to establish an asset that can be used to finance major or exceptional costs in their lives. Extension services combined with clear price incentives rewarding for quality would be necessary though for the long-term sustainability of this livelihood activity, as smallholder tree growers struggle to produce high quality wood and lose part of the potential return on their investment.

Success of promotional forest plantation policies and incentives depends on the socioeconomic context where they are applied, the overall political and market environment in the country or region, the perseverance of the supportive policies, and the relevance of the incentives to target and overcome the actual hindrances for tree growing. Lao PDR is an example of a country where promotional policies and incentives for tree growing have failed to meet smallholder needs. The land allocation mechanism and related laws and regulations should be revised to allow smallholders to access more land for tree growing. Similarly, incentives should be revised to better address smallholder needs and bureaucracy on plantation establishment, management and wood sales. For long rotation tree species such as teak or Dipterocarps, some PES system could potentially provide additional incentives to make the long-term investment possible, also for smallholders.

Secure land tenure and demand for wood are necessary conditions for smallholder tree growing. Governments are in a key role in establishing the regulatory environment for tenure and in providing access to land for tree growing. Direct incentives, well-functioning markets, and knowledge and capacity have been present in the majority of the cases where smallholder tree growing has expanded. Although all these factors can be improved by non-governmental actors, government investments are often necessary to create a push-effect for smallholder tree growing.

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Appendix 1 - Farmer questionnaires

Tree farmer questionnaire

Village Name_____ # _____

Date: _____

Country	
Region	
District	
Village	
Sub-village	

1. Household information:

1.1 Name of the interviewee:	Mr/Mrs/Ms	Education:
1.2 Head of the household		
1.3 Marital status:		
1.4 Age:		
1.5 Ethnic group		
1.6 Family members (number) living at the farm, number of children	Adults Children Children still living with parents	
1.7 How many years have you/has your family owned your farm?	Interviewee since Family since	
1.8 Have you any plans to sell your farm in near future (in coming 5-10 yrs)?	Yes../ No	
1.9 Do you have a formal title for your lands?	Yes../ No	

Current holder name (husband/wife/both/other)		
1.9 Who will continue farming after you in the farm?		
1.10 Heritance to	several children	
	one of the children	
	another person	
	The farm will be sold	
	Other, what?	
1.11 Total HH income last year (2014) (agriculture and other sources: wood sales, labour, other business – specify the most important sources) Was last year's income in a normal level?		

2. Farm details

2.2	Do you live permanently in the village/your farm? yes /no /yes, except ___ If you do not live permanently in the village/on your farm, how many kilometres distance you have from your home to the farm? _____ km Do you own other farms? Total area of your farms? yes/ no _____ ha/acres
2.3 How many persons work in the farm	_____ (permanent) Are you using temporary paid labour? _____ man days/year

2.4 Main crops in the farm and their area (in ha/acres) and production	Crop	Area (ha/acres), production (bags/kg per year)	Own use/sales (bags)
2.5 Self-sufficiency of food	Which foods your farm produces sufficiently for your own use?		
2.6 Number of livestock	How many animals you have in your farm (number, sales/own use)		
2.7 Do you have any (natural) forest in your farm	ha/acres		
2.8 Other land	How much other land you have in your farm (ha/acres)?		
	Wasteland		
	Fallow land		
2.9 Ownership	Type of ownership of the planted areas: private, customary, leasehold, community lands		

3. Tree plantation details

3.1 Total area of the farm (ha/acres)	(both agricultural and forest land)
	Total area

3.2 Tree plantation area	Species planted, year of planting, former use of land			
	Species	Area	Year	Former use of land
3.3 Purpose of the tree plantation	Is your tree plantation for			
	Commercial wood production			
	Fire wood			
	Own use (construction, firewood)			
	Do/did you have a plan where to sell the trees - where? yes / no _____ _____			
3.4 Seedlings and materials	Where did you get/buy seedlings/seeds used on your plantation? Seeds: Seedlings/stumps:			
3.5 Management	What kind of forest management activities have been carried out on your plantation?			
		Year	Year	Year
	firelines			
	replanting			
	weeding			
	slashing			
	pruning			
	thinning			
	none – why?			
3.6	If you're doing pruning, at which age you normally do the first pruning and how many times you do it before harvest?			

<table>
<tr><td></td><td colspan="3">Why you’re doing pruning (what benefits you see in pruning)?</td></tr>
<tr><td rowspan="6">3.7 Investment</td><td colspan="3">How much have you invested your own money and your family time on your plantation? When? Visited teak plot</td></tr>
<tr><td>Phase</td><td>Time (days/yr) – own time</td><td>Money (hired labour, seedlings)</td></tr>
<tr><td>Establishment (Year meaning plot establishment year)
Year_____</td><td></td><td></td></tr>
<tr><td>Slashing
Year_____
Year_____
Year_____</td><td></td><td></td></tr>
<tr><td>Pruning
Year_____
Year_____
Year_____</td><td></td><td></td></tr>
<tr><td>Thinning, Final cut</td><td></td><td></td></tr>
<tr><td>3.8</td><td colspan="3">Have you been using intercropping on this plantation? How many years?

Yes / No _____years</td></tr>
<tr><td>3.9</td><td colspan="3">Have you been using intercropping on other woodlots? For how many years?

Yes / No _____years</td></tr>
<tr><td>3.10</td><td colspan="3">After harvesting the trees, are you planning to grow agricultural crops on your woodlots? For how many years? If not, what will happen to the woodlot area?

Yes / No _____years</td></tr>
</table>

3.11	At which age you're planning to sell/cut the trees on this woodlot? _____yrs At which age you normally cut/sell trees? _____ yrs		
3.12 Expectations for tree planting	What kind of benefits and problems you see in tree planting?		
a) Benefits	fodder/fire wood/construction wood		
	some NTFP for own use or sale		
	soil protection from erosion		
	protection of biodiversity/nature		
	water management (improving water quantity/quality)		
	protection of the farm from encroachment/illegal invasion		
	farm value increase (to sell/inherit)		
	protection against wind/wind erosion		
	improving the landscape		
	providing shade		
	improve local microclimate		
	improving the recreational values and touristic potential		
	combat against climate change/carbon credits		
	opportunities to work on the farm		
	others (specify)		
b) Problems	reduced availability of agricultural/pasture land		
	deterioration of landscape values		
	excessive amount of work		

	too much shade	
	high investment risk	
	long period before trees produce income	
	inadequate information/knowledge	
	high tree mortality (specify reason)	
	complicated procedures with authorities	
	conflicts with neighbours of land use	
	others (specify)	
3.13 Firewood and timber	Where do you get your timber now? And in the future?	
3.14 Incentives	Have you participated or do you currently participate in a reforestation/afforestation programme: no / yes name of the programme	
	How many years did you participate/you have participated in the programme years	
	Have you received support to your tree plantations? From where/whom? yes../ no	
	What kind of support you received and how much?	

	credit/loan	
	grant	
	seedlings	
	fertilizers	
	labour	
	extension support	
	other	
3.15	If you have received a private credit/loan for tree planting, have you been or will you be able to pay it back? yes../no../ don't know Why?	
3.16	Significance of the incentives received – was it important in decision making on plantation establishment?	
	Very important	
	somewhat important	
	not important	
3.17	How much do you estimate that you have lost potential agricultural produce due to tree planting (amount/value – annual and total) – bags of agricultural produce/ha(/acre)	
3.18 Organization	Are you a member in a tree growers association or a forest cooperative? yes / no What kind of support you have received through the association/cooperative?	

4. Extension support and Plantation management

4.1 Training	Where did you learn tree plantation management?

<table>
<tr><td></td><td colspan="4"></td></tr>
<tr><td rowspan="8">4.2 Technical support & management</td><td colspan="4">Have you received any extension/technical support in plantation establishment and management? List support below.
Which organization provided the extension service? (NGO, government, private, TGA/cooperative)
How would you qualify the extension services (very good/sufficient/poor)</td></tr>
<tr><td>Plantation phase/activity (planning, species/site selection, preparation, establishment, replanting, early years management such as weeding, pruning, slashing thinnings, marketing/selling, final cut)</td><td>Year</td><td>Organization</td><td>Quality of service</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>4.3</td><td colspan="4">Have you had problems in tree growing? What kind?</td></tr>
<tr><td rowspan="2">4.4</td><td colspan="4">How do you qualify plantation tree growth (by species)? Excellent / Good / Average / Low</td></tr>
<tr><td colspan="2">species</td><td colspan="2">growth</td></tr>
</table>

<table>
<tr><td></td><td colspan="4">Visited plot</td><td></td></tr>
<tr><td></td><td colspan="4">Other woodlots</td><td></td></tr>
<tr><td>4.5</td><td colspan="5">Have you had any conflicts with neighbours/community members on tree planting/land use? What kind (e.g. water, pastoralism, fire)? How did you solve it?</td></tr>
<tr><td>4.6 Sales</td><td colspan="5">Have you already sold trees from your plantation (last sale)?</td></tr>
<tr><td></td><td>Species</td><td>Year</td><td colspan="2">Volume sold/no of stems – age of the trees
If selling timber - specify</td><td>price per m3/stem – if not known, total value</td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td></td><td colspan="5">How did you sell your trees
(Marketing channel: middleman, directly to a manufacturer, through cooperative/association, other)?</td></tr>
<tr><td>4.7</td><td colspan="5">How the volume or number of trees to be sold was assessed? (visual assessment or grading rules – and which, if known)?

Who performed measurement and grading on the trees, did you observe?

Were the sold trees measured in advance or at the moment of sale or at all?

What are local ways of measuring normally? (tree girth (where on the tree), LAR (cubic yard, but they put 1.2m), pole classes (dbh etc), allowances (quite some informal but wide spread ones, like 10cm either end and 1-3 cm)</td></tr>
</table>

4.8	How was the price negotiated/agreed? Did you have any knowledge of wood market prices at the time of sale? Do you know what the logs are used for and how much they are worth at certain point (if they know value at any point of sale e.g millgate, ex works suqare log, square landed vietiane/china etc.)?
4.9	Have you had difficulties in selling? What kind?
4.10	What procedures you have to go through to get the cutting/selling licence?
4.11	How much has it cost to get the necessary licences (government fees/other costs) _____ fees _____ other costs
4.12	Who performed the cutting and sawing and what tools were used? How long did it take to buyer to harvest the trees? How many persons were working in harvesting? How long did it take to transport the logs from the yard?
4.13	Did you receive the money

	a) right after measurement b) at the time of harvest/grading c) I have not received the money (yet)
4.14	Is your contract of sale detailed and scheduled, so that you know the process? Yes / No
4.15	If you apply thinning - what is obtained wood used for? Have you been able to sell wood from thinnings and where?
4.16 Future	Are you planning to plant more trees in coming 5 years? Absolutely / Most likely yes / Maybe / Most likely not / No / Don't know If yes, why and under which conditions? If not, why?
4.17	Which species you would prefer to plant and why? Species: Why?
4.18	Have you ever been planting trees on a mixed stand? Do you prefer plantation planted with single species or mixed plantations? Why? Single / mixed
4.19	How are you planning to use the trees planted in the future (by species)?

		Species	
	Cut and sell timber		
	Cut firewood		
	Keep the plantation as reserve		
	Other (what?)		
4.20	In your opinion, what is a good tree plantation (describe with own words)? Do you think your tree plantation is good? Why? Yes/No		
4.21	Would you apply for tree planting support/incentives in the future? Yes / No Why?		
4.22 How would you use/invest the extra money from tree planting?			

Coding for the data entry and analysis

1.1	**Sex**	
	Female	1
	Male	0
	Education	
	None	0
	Primary school 1-3 years	1
	Primary school 4+ years	2
	Secondary school	3
	Vocational education	4
	High school	5
	Univ.	6
1.2	**Head of household**	
	Interviewee	1
	Spouse/other	0
1.3	**Marital status**	
	Married	1
	Widow	2
	Unmarried	3
	Ethnic group	
	Mbwena	1
	Hehe	2
	Go'Go	3
	Mpangwa	4
	Plans to sell farm	
	No	0
	Yes	1

1.9	**Who will farm after you**	
	several family members (children, grandchildren, spouse, siblings)	1
	one family member (child, spouse, sibling)	2
	another person	3
1.11	**Inheritance**	
	several family members (children, grandchildren, spouse, siblings)	1
	one family member (child, spouse, sibling)	2
	another person	3
	other	4
1.12	**Annual income**	
	0-50 000	1
	50 000-200 000	2
	200 000-500 000	3
	500 000-1 000 000	4
	1 000 000-2 000 000	5
	2 000 000-4 000 000	6
	4 000 000-6 000 000	7
	6 000 000+	8
2.2	**Terrain**	
	Flat	1
	Undulating	2
	Gentle slope	3
	Steep slope	4
2.4	**Agricultural crops**	
	Maize	1
	Beans	2
	Fingermillet	3
	Vegetables	4

	Irish potatoes	5
	Sweet potatoes	6
	Avocados	7
	Tea	8
	Coffee	9
	Tree nursery	10
	Wheat	11
	Sunflower	12
	Bananas	13
	Cassava	14
	Peas	15
2.6	**Animals**	
	Chicken	1
	Pigs	2
	Goats	3
	Cows	4
	Sheep	5
	Geese/Ducks	6
2.9	**Type of ownership**	
	Private	1
	Customary	2
	Leasehold	3
	Community	4
3.2	**Tree species**	
	Pine	1
	Eucalyptus	2
	Cyprus	3
	Pine + Cyprus (mixed plantation)	4

	Pine + Euca (mixed plantation)	5
	Black wattle	6
	Hagenia abyssinica	7
	Syzygium sp.	8
3.2	**Former use of land**	
	Not known	0
	Agriculture	1
	Open land/grass land	2
	Grazing land	3
	Tree plantation	4
3.3	**Purpose of the plantation**	
	Commercial	1
	Firewood	2
	Own use	3
3.3	**Where to sell trees**	
	No plan	0
	Dealers in the village	1
	Dealers visiting village (or in other village)	2
	Selling timber (processing him/herself)	3
	Other	4
3.4	**Benefits (cont. From list)**	
	Contribution towards dowry	15
	Improve soil fertility	16
	Ability to invest (e.g., in more plantations, bean seeds)	17
	Environmental values (e.g. air quality, conservation, etc.)	18
	Produce seeds for his own woodlot	19
	Problems (cont. From list)	
	Low availability of seedlings	11

	Low availability of seeds, or of high quality seeds	12
	High costs (e.g. to buy seeds/seedlings, to adequately manage plantations)	13
	Damage from grazing animals	14
	Land grabbing	15
3.5	**Firewood**	
	Own woodlots (waste)	1
	Neighbours' woodlots	2
	Own acacia woodlot	3
	Natural forest	4
	Timber	
	Own woodlots	1
	Buy from the village	2
	Buy from dealers	3
3.6	**Significance of the incentives**	
	very important	1
	somewhat important	2
	not important	3
3.7	**Type of support**	
	Seedlings	1
	Other materials	2
	Extension	3
	Support from other members	4
	Access to land for PFP planting	5
4.1	**Where learned tree plantation management**	
	Parents / family	1
	Neighbours, other villagers	2
	District forest officer	3

	Missionaries	4
	Tree planting programme	5
	At school	6
	Self-taught	7
	Other	8
	TGA	9
4.2	**Seeds**	
	Collected from own/neighbour's woodlots	1
	Bought from TANWAT/elsewhere	2
	Bought from TGA	3
	Other	4
	Bought from TFA (in Njombe)	5
	From support programme/government	6
	Seedlings	
	Grown at home	1
	Bought from village/neighbor village	2
	From TGA nursery	3
	From tree planting programme	4
	Other	5
4.4	**Activities**	
	General planning of plantation (water management, seedling selection, spacing, rotation, etc.)	1
	Assessing value of timber	2
	Planting	3
	Early years management (weeding, spraying herbicides/pesticides)	4
	Pruning	5
	Thinning	6
	Marketing/selling	7
	Fire line training	8

Income Generating Activities (on cash crops for additional income)	9
Fertilizing	10
Mixing plantations with other activities (e.g., bean cultivation, bee-keeping)	11
Avocados	12
Nursery activities	13
Forest mensuration (tools and methods for measuring trees)	14
Quality of service	
Very good	1
Good	2
Average	3
Poor	4
No answer	0
Problems in tree growing	
None	0
Long distance to wood lot(s)	1
Seedlings dying	2
Labor to do establishment (not enough, low quality)	3
Labor to do management (not enough, low quality)	4
Fire	5
Protection of water resources	6
Pests/diseases	7
Transport of seedlings (long distances or poor road conditions)	8
Theft	9
Slow growth of trees (poor site)	10
Poor seeds/seedlings	11
Lots of grasses/weeds	12
Not enough seedlings	13
How do you qualify plantation growth	

	Very good	1
	Good	2
	Average	3
	Poor	4
4.6		
	Selling channel for trees/timber	
	Middleman in the village	1
	Middleman outside village	2
	To manufacturer	3
	Other	4
	Pricing method	
	Negotiating with one buyer	1
	Negotiating with several buyers	2
4.7	**Motivation to plant more**	
	Now has more information on plantation management	1
	To increase income	2
	No clear answer	3
	To leave assets for children (next generations)	4
	Conditions	
	No conditions	0
	If more land available	1
	Depends on the time they have to plant/manage alone (cannot hire help)	2
	If still alive	3
	If have enough money to purchase extra land	4
	If have access to quality seeds	5
	If have access to education on plantation management	6
	Species preference	
	Pine	1

Eucalyptus	2
Cyprus	3
Native	4
Acacia	5
Reason	
Grows fast	1
Long term investment	2
Quick returns	3
Easy to sell/ready market	4
Easy to buy (accessible)	5
Cheap to buy	6
Easy to plant/manage	7
Can receive good price	8
Receive multiple benefits (for personal use and selling)	9
Improves soil fertility	10
Useful for marking boundaries	11
Can plant agricultural crops after harvest	12
More resistant	13
Good quality	14
Single or mixed plantation?	
Single	1
Mixed	2
Reason	
Different growth rates (competition)	1
Eucalyptus sprouts (e.g., would invade adjacent agricultural plots)	2
No clear answer	3
Difficulties harvesting in mixed (e.g. damage to other remaining species)	4
Buyer preference	5

How are you planning to use the trees planted in the future (by species)?	
Pine	1
Eucalyptus	2
Pine & Eucalyptus	3
Cyprus	4
Other	5
Reason to apply for incentives in the future	
To get extension services	1
To get seeds/seedlings	2
To get inputs (fertilizers, herbicides)	3
To get tools	4
To be able to increase plantation area or intensity	5
To make a better profit	6
Other	7
To get a loan	8
No clear answer	9
Investment of funds	
Send children to school	1
Build/repair a house	2
General home/family use	3
Emergencies	4
Car/motorcycle	5
Travel	6
Healthcare	7
Invest in a business	8
Purchase more land	9
Savings	10
Plantation/farm-related purchases and management	11

Farmer questionnaire for non-planters

Code _____

Date: _____

Country	
Region	
District	
Village	
Sub-village	

1. Household information:

1.1 Name of the interviewee:	Mr/Mrs/Ms	Education:
1.2 Head of the household:		
1.3 Marital status:		
1.4 Age:		
1.5 Ethnic group (to be specified by country):		
1.6 Family members (number) living in the household, number of children	members children	
1.7 How many years have you/has your family lived on your farm?	Interviewee since	Family since
1.8 Do you own any land? Have you any plans to sell your farm in near	Yes../ No Yes../ No	

future (in coming 5-10 yrs)?			
1.9 Who will continue farming after you in the farm?			
1.10 Do you have a CCRO for you lands? Whose name is in the CCRO?			
1.11 Heritance to	several children		
	one of the children		
	another person		
	The farm will be sold		
	Other, what?		
1.12 Total HH income last year (2014)) (agriculture and other sources, labour, other business) Was last year's income in a normal level?			
1.13 Share of income from farm and from other labour (working outside of the farm) – what was the most important source of income?			

2. Farm details

2.3 Farm occupancy	Do you live permanently in the village? yes /no /yes but only ___ months per year If you do not live permanently in the village/on your farm, how many kilometres distance you have from your home to the farm?

<table>
<tr><td></td><td colspan="3">_____ km

Do you own other farms? Total area of your farms?

yes/ no _____ ha/acres</td></tr>
<tr><td>2.4 Work force</td><td colspan="3">How many persons work in the farm?

_____(permanent)_____(temporary)</td></tr>
<tr><td rowspan="10">2.5 Main crops in the farm and their area (in ha/acres) Specify if on rented land</td><td>Crop and production (bags)</td><td>Area (ha/acres)</td><td>Own use/sales (bags)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Which foods your farm produces sufficiently for your own use?</td></tr>
<tr><td rowspan="7">2.7 Number of livestock</td><td colspan="3">How many animals you have in your farm (number)</td></tr>
<tr><td>Variety</td><td colspan="2">Number of animals</td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td rowspan="2">2.8 Other land</td><td colspan="3">Do you have any (natural) forest you have in your farm?

_____ha/acres</td></tr>
<tr><td colspan="3">How much other land you have in your farm (ha/acres)?</td></tr>
</table>

	Wasteland	
	Fallow land	
2.9 Ownership	Type of ownership of: private / customary / leasehold / community lands	

3. Tree planting interest

3.1 Future	Are you planning to plant trees in coming 5 years? Absolutely / Most likely yes / Maybe / Most likely not / No / Don't know If yes, under which conditions? If not, why? Have you ever considered planting trees? Why? yes / no		
3.2 Expectations for tree planting	If you're planning to plant, what kind of benefits and problems you expect in tree planting? Probability scale 0-4: 0 not expected at all, 1 minor probability 2 may or may not occur 3 likely to occur 4 certain to occur		
	Expectation	Before	Now
Benefits	fodder/fire wood/construction wood		
	some NTFP for own use or sale		
	soil protection from erosion		

	protection of biodiversity/nature		
	water management (improving water quantity/quality)		
	protection of the farm from encroachment/illegal invasion		
	farm value increase (to sell/inherit)		
	protection against wind/wind erosion		
	improving the landscape		
	providing shade		
	improve local microclimate		
	improving the recreational values and touristic potential		
	combat against climate change/carbon credits		
	opportunities to work on the farm		
	others (specify)		
Problems	reduced availability of agricultural/pasture land		
	deterioration of landscape values		
	excessive amount of work		
	shade		
	high investment risk (FIRE)		
	long period before trees produce income		
	inadequate information/knowledge		
	high tree mortality		
	complicated procedures with authorities		
	conflicts with neighbours of land use		
	others (specify)		
3.3 Type of plantations preferred	Which species you would prefer to plant? Why? Species: Why?		

<table>
<tr><td></td><td></td></tr>
<tr><td></td><td>Do you prefer plantation planted with single species or mixed plantations? Why?

Single / mixed
Why?</td></tr>
<tr><td rowspan="6">3.4 Purpose of planned tree plantations</td><td colspan="3">How are you planning to use the trees planted in the future (by species if known)?</td></tr>
<tr><td></td><td>Species</td><td></td></tr>
<tr><td>Cut and sell timber</td><td></td><td></td></tr>
<tr><td>Cut firewood</td><td></td><td></td></tr>
<tr><td>Keep the plantation as reserve</td><td></td><td></td></tr>
<tr><td>Other (what?)</td><td></td><td></td></tr>
<tr><td rowspan="4">3.5 Knowledge and need for support

Specifying question on government role</td><td colspan="3">Do you already have knowledge how to establish and manage a tree plantation?</td></tr>
<tr><td colspan="3">Who could advise on your tree plantation establishment and management?</td></tr>
<tr><td colspan="3">Do you know any incentives for tree planting (technical, financial) and would they be important to establish a plantation?</td></tr>
<tr><td colspan="3">Would you apply for tree planting/reforestation/afforestation incentives?</td></tr>
</table>

	yes / no Why?
3.6 How would you use/invest the extra money from tree planting?	

Coding for data entry and analysis

Question nro	Answer options	Code
1.1	**Sex**	
	Female	1
	Male	0
1.2	**Head of household**	
	Interviewee	1
	Spouse/other	0
1.3	**Marital status**	
	Married	1
	Widow	2
	Unmarried	3
	Ethnic group	
	Mbwena	1
	Hehe	2
	Go'Go	3
	Mpangwa	4
	Plans to sell farm	
	No	0
	Yes	1
	Maybe	2
1.9	**Who will farm after you**	
	No one	0
	several family members (children, grandchildren, spouse, siblings)	1
	one family member (child, spouse, sibling)	2
	another person	3
1.11	**Inheritance**	
	No one	0

	several family members (children, grandchildren, spouse, siblings)	1
	one family member (child, spouse, sibling)	2
	another person	3
	other	4
1.12	**Annual income**	
	0-50 000	1
	50 000-200 000	2
	200 000-500 000	3
	500 000-1 000 000	4
	1 000 000-2 000 000	5
	2 000 000-4 000 000	6
	4 000 000-6 000 000	7
	6 000 000+	8
	No own income, relatives supporting	9
2.3	**Do you live permanently on your farm?**	
	No	0
	Yes	1
	Yes, but part-time	2
	Renting agricultural land	3
2.2	**Terrain**	
	Flat	1
	Undulating	2
	Gentle slope	3
	Steep slope	4
2.5	**Agricultural crops**	
	Maize	1
	Beans	2
	Fingermillet	3

	Vegetables	4
	Irish potatoes	5
	Sweet potatoes	6
	Avocados	7
	Tea	8
	Coffee	9
	Tree nursery	10
	Wheat	11
	Sunflower	12
	Bananas	13
	Cassava	14
	Peas	15
2.7	**Animals**	
	Chicken	1
	Pigs	2
	Goats	3
	Cows	4
	Sheep	5
	Geese/Ducks	6
2.9	**Type of ownership**	
	Private	1
	Customary	2
	Leasehold	3
	Community	4
3.1	**Planning on planting in next 5 years?**	
	Absolutely	1
	Most likely yes	2
	Maybe	3

	Most likely no	4
	No	5
	Don't know	6
	Reason, If will/won't plant in coming 5 years (AND why did/didn't consider)	
	No available land (N)	1
	To make/increase profits from land (Y)	2
	No clear answer	3
	Health problems, or old age	4
	Large distance to available land	5
	Other	6
	To create rotations of agriculture & forestry	7
	To increase income	8
	To have an "emergency fund" to solve problems	9
	To establish an asset for children for their future	10
	To have multiple benefits (timber, construction & firewood)	11
	Taking care of parents - no time	12
	Has previously planted trees	13
	Conditions	
	No conditions	0
	If can get access to more land	1
	Depends on the time, they have to plant/manage alone (cannot hire help)	2
	If still alive/health allows	3
	If available land was closer	4
	If land ownership was secure	5
3.2	**Benefits, (continued from list)**	
	Contribution towards dowry	15

	Improve soil fertility	16
	Ability to invest (e.g., in more plantations, bean seeds)	17
	Environmental values (e.g. air quality, conservation, etc.)	18
	Income (sale of timber)	19
	Problems (continued from list)	
	Low availability of seedlings	11
	Low availability of seeds, or of high quality seeds	12
	High costs (e,g, to buy seeds/seedlings, to adequately manage plantations)	13
	Harm from grazing animals	14
	Land grabbing	15
	High competition in the markets because so many tree planters	16
3.3	**Species preference**	
	Pine	1
	Eucalyptus	2
	Cyprus	3
	Native	4
	Acacia	5
	Reason	
	Grows fast	1
	Long term investment	2
	Quick returns	3
	Easy to sell/ready market	4
	Easy to buy (accessible)	5
	Cheap to buy	6
	Easy to plant/manage	7

	Can receive good price	8
	Receive multiple benefits (for personal use and selling)	9
	Produces good quality timber	10
	Because it is popular now (others are doing it)	11
	Rainfall formation/water management	12
	Good to combine with bees	13
	Does not consume a lot of water	14
	Single or mixed plantation?	
	Single	1
	Mixed	2
	Reason	
	Eucalyptus grows faster than pine (competition)	1
	Eucalyptus sprouts (e.g., would invade adjacent agricultural plots)	2
	No clear answer	3
	Difficulties harvesting (damage to other remaining species)	4
	Maximize profits	5
	In mixed plantation performance of the trees is poor	6
	To get both soft and hard wood at the same time	7
	Easier to manage	8
	Other	9
3.4	**How are you planning to use the trees planted in the future (by species)?**	
	Pine	1
	Eucalyptus	2
	Pine & Eucalyptus	3
	Cyprus	4

	Other	5
3.5	**Who could advise you on tree plantations?**	
	No clear answer or idea	0
	PFP	1
	People in the village/neighbours	2
	Family	3
	Other	4
	Agricultural extension officer	5
	District forest officer	6
	Village TGA	7
	Reason to apply for incentives in the future	
	To get extension services	1
	To get seeds/seedlings	2
	To get inputs (fertilizers, herbicides)	3
	To get tools	4
	To be able to access land for plantation	5
	To make a better profit	6
	Other	7
	To get a loan	8
	No clear answer	9
	TO get market information	10
	To be able to plant larger areas	11
	To have better success in planting activities	12
	He's able to plant trees without support	13
	Investment of funds	
	Send children to school	1
	Build/repair a house	2
	General home/family use	3

Emergencies	4
Car	5
Travel	6
Healthcare	7
Invest in a business	8
Purchase more land	9
Savings	10
Plantation/farm-related purchases and management	11
Reinvesting in tree planting	12

Appendix 2 - Field sheet for forest inventory

Village		Plot id		Altitude (m)	
Woodlot area		Plot size		Slope (%)	
Lat		R-multiplier		Est. class	
Lon		Pruning class		Est. year	

Measurer:

_____

Observations:

_____

Tree	D (cm)	Branch H Dead (m)	Brach H Living (m)	Total H (m)	Trestima	Defect class	Observations
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

16							
17							
18							

Appendix 3 - Enabling factors and related indicators

TEN - LAND & FOREST TENURE	
Strength of land ownership Indicator:	Factor is positive if: ≥3 indicators are positive Indicator is positive if:
1. Existing private land tenure system and its enforcement (strong vs. weak), validity of customary land tenure and allocation system	1. Either a formal land tenure system is in place and enforced OR customary land ownership is considered strong (and has some legal status)
2. Land classification and allocation for agriculture and forestry (and other uses such as infrastructure, mining etc.)	2. Land use planning and allocation mechanisms (if any) respect land and tree tenure (also under tree plantations) and allow tree planting
3. Reports on land grabbing	3. There are no reports on recurrent and extensive land crabbing occurrences in rural areas
4. Limitations on land holding size and/or external/foreign land investors actions	4. The land holding size is regulated and/or foreigners/non-community members' rights to invest in land are restricted
DEMSUP - DEMAND - SUPPLY BALANCE	
Domestic demand for wood and wood products and how it is met Domestic demand - Indicators:	Factor is positive if there is a strong domestic or/and export-oriented wood demand. Domestic demand is positive if ≥3 indicators are positive
1. Wood demand vs. national supply	1. The AAC (source FAO FRA) per capita is less than the estimated wood consumption per capita (Note: wood fuel also covered)
2. Deforestation rate;	2. Annual deforestation rate 2005-2015 is >0.5%

3. Share of wood energy in the national energy balance	3. >50% of the population relies on wood-based energy as their main energy source
4. Rate of illegal logging and purpose (estimate: considerable/medium/minor – MSMEs or energy)	4. Illegal logging of natural forests is considered as a minor problem (Source: in the absence of official/scientific reports NGO reports, expert opinions)
5. Demand for ES services from forests (watershed mgmt., erosion control, climate change & agricultural systems - shade…)	5. National policies recognize environmental problems caused by deforestation, need for improved environmental services from planted forests AND allocate resources to compensate for the environmental services produced by planted forests
Industrial wood demand and how it is met Industrial/export demand - Indicator:	Industrial/export demand is positive if ≥3 indicators are positive:
1. Promotional policy targets and means for forest-based production/industry: (taxation, export/import policies on wood and wood products)	1. There are incentives for forest industries development (e.g. log export ban, tax reliefs for investments, specific tariffs etc.)
2. Existing forest industry (large/MSMEs): type, production capacity/volume, wood demand and sourcing (natural forest, own plantations, imports, out-grower schemes)	2. There is a viable/growing forest industry in the country, using planted forests as their supply source

3. Sufficient infrastructure for industry development and markets to function (road network, energy availability, ports)	3. The national (electricity) production+import is sufficient to cover the industrial and consumer demand https://unstats.un.org/unsd/energy/balance/ (power cuts or seasonal variation in availability of electricity, energy price for industries), road network covers the country and is under maintenance/at least in reasonable condition.
4. Wood and wood product imports, is the country net importer or exporter?	4. The country is either a) a net importer of forest products OR b) there is a strong export-oriented forest industry in the country or round wood export is significant
AGR - LOW AGRICULTURAL PRESSURE	
Agricultural policy incentives or disincentives for a) land conversion to agriculture or b) to improve ES for agriculture through tree planting/growing/forest management Indicator:	The factor is positive if ≥5 indicators are positive Indicator is positive if:
1. Existence of agricultural promotion policies and strategies which discourage land conversion to agricultural production	1. Positive if agricultural policies aim to restrict agricultural area expansion and e.g. stabilize slash and burn farming - negative if land conversion to agriculture is incentivised (e.g. formalizing land tenure, subsidies paid based on cultivated area).
2. Existence of agricultural promotion policies and strategies which encourage tree planting e.g. for ES or income diversification	2. Positive if agricultural policies recognize tree planting and e.g. environmental services trees and tree plantations have, and encourage tree growing, or e.g. mention agroforestry systems as a mean to improve environmental services, productivity, and income diversification. Multipurpose trees (e.g. fruit trees) are considered as tree growing (as well as rubber and Arabic gum) but not palm oil.

3. Agricultural intensification targets and means	3. Agricultural policies, strategies (and financing) aim to increase productivity of the main crops
Are demographic patterns and agricultural technology development increasing or decreasing pressure for more agricultural land? Indicators:	Indicator is positive if:
4. Population growth	4. Population growth <1.5%
5. Level of urbanization	5. Urban population is >40% and urbanization is a constant trend. NOTE two sides of the coin: urbanization removing partly population pressure from rural areas as such but on the other hand increasing demand for agricultural (and forest) products.
6. Arable land per capita	6. Arable land per capita >0.15 ha
7. Productivity of the main subsistence crops (in agriculture)	7. Main subsistence crops in the country: productivity at least the world average (vs. FAO figures)
8. Competition with high value/demand cash crops	8. Positive if there are no recent "booms" of major cash crops in the country (such as oil palm, rubber, soy bean)
9. Availability of degraded land suitable for tree planting	9. FAO FRA/NFI + forest policy & legislation
MACRO - MACROECONOMIC AND POLITICAL STABILITY	
1. GNI and GDP growth	1. The country is a) classified as at least lower middle-income country AND/OR the annual GDP growth has been >5% for 10 years
2. Political stability	2. https://www.theglobaleconomy.com/rankings/wb_political_stability/

MAR - WOOD MARKETS & PRICING	
Market and pricing mechanisms for (smallholder) wood Indicators:	Indicator is positive if ≥2 indicators are positive:
1. Timber prices and pricing mechanisms (market prices vs. regulated markets)	1. Positive if the wood pricing system for smallholder produced wood is market based; negative if the prices are strictly regulated OR out grower schemes use fixed prices without an option to sell elsewhere
2. Existing market mechanisms vs. dependence on middle men on wood sales	2. Positive if wood markets from farmer perspective can be considered competitive (access to market information, alternative channels to sell wood)
3. Smallholder tree growers are able to sell their produce to the industries	3. There are a) either out grower arrangements between private tree growers (smallholders) OR b) a working market mechanism linking tree growers and wood industries
KNOW - CAPACITY AND KNOWLEDGE	
Access to knowledge and inputs Indicators:	Factor is positive if ≥4 of the indicators are positive. Indicator is positive if:
1. History and tradition of (smallholder) tree planting and growing in the country, incl. agroforestry systems used	1. The country has an established tree planting culture, e.g. by the government plantations, private plantations or through agroforestry systems
2. Extensions systems and their reach	2. There is a (government) forest extension network available and it has sufficient knowledge and capacity to support tree growers (possibly also through tree grower associations or out-grower scheme agreements)
3. Smallholder access to financing	

	3. Smallholder tree growers have access to additional financing for tree planting/management activities e.g. farmer banks, loans for forestry. This can also be arranged through out-grower arrangements with the industries.
4. Existence and capacities of farmer and tree grower organizations	4. Tree growers are organized and their organizations have at least some capacity to support tree growing activities and wood sales
5. Availability of technical inputs (nurseries-seeds-seedlings, tools, fertilizers, herbicides, trainings)	5. Tree growers have at least reasonable access to seeds/seedlings, and other crucial inputs (depending on the type of plantations)
6. Available forest education (levels: vocational, secondary, univ.)	6. The country has forest education available at all levels
7. Forest sector research and how it supports smallholder tree growing	7. There are forest/agricultural research organizations active in the country working on topics relevant to smallholder tree growing
DIRINC - DIRECT INCENTIVES	
Precondition: forest policy sets a long term (>15 yrs) target to promote private forestry and smallholder tree growing Indicator: Are direct incentives clearly described in the government policies and applied in reality? Is there sufficient finance in the gov. budget (incl. donor financed project-based support, or in NGO/company budget	Indicator is positive if: Policy in place, direct incentives are applied (seedling, grants etc. to tree growers, extension services, allocation of (degraded) public land for tree growing) and they significantly increase the attractiveness of tree growing for smallholders vs. other land uses.

to implement the incentives? How many direct incentives are applied and are they significantly reducing the tree growing costs/improving profitability of tree growing?	
INDIRINC - INDIRECT INCENTIVES	
Precondition: forest policy sets a long term (>15 yrs) target to promote private forestry and smallholder tree growing Are indirect incentives clearly described in the policies and applied in reality? Government resourcing and financing to implement the incentives (incl. donor financed project-based support). Does the regulation and RED TAPE on plantation establishment / plantation management / harvesting and wood sales encourage or discourage tree planting activity, and is the regulation enforced in reality?	Policy in place, indirect incentives applied (e.g. removal of bureaucratic barriers, research, market development, land tenure related benefits etc.), encouragement of forest industry investments. **Indicator is positive if** the indirect incentives have significantly improved the operating environment for tree growing (e.g. services and training for tree growers, market development, etc. See Table 3). Regulation and bureaucracy on smallholder tree growing is at reasonable level and its costs are modest vs. the expected profits from tree growing. Regulation and bureaucracy can be considered supportive for smallholder tree growing if the fees and licences are not applied in reality.

Appendix 4 - Sensitivity Analysis

Setting the thresholds and sensitivity analysis for Step 1 (necessary factors)

Absence of comprehensive, comparable and reliable statistics or maps on smallholder tree growing in the case-study countries does not allow a systematic numeric description and comparison of the outcome between years and countries. Instead, estimates on smallholder tree growing area were searched from available statistics, studies and other secondary sources to build understanding of tree growing trend and its strength. The scale measuring the outcome was set simply as weak-moderate-strong, and 'moderate' and 'strong' status were considered as a positive outcome receiving value [1].

The tree growing boom was at its initiation stage in Tanzania, Uganda and Lao PDR in 2005 (TNZ05; UGA05 and LAO05) and mid-2000's could be called a 'tree growing tipping point' in these countries. Therefore, a sensitivity analysis was carried out with both values of the outcome in these countries. Presence of the outcome [1] in Lao PDR and absence [0] in Tanzania and Uganda resulted in contradictions of configurations as shown in Table 24.

Table 24. Truth table – Sensitivity analysis of the outcome

CASEID	TEN	DEMSUP	AGR	MACRO	OUTCOME -sensitivity
LAO90	0	0	0	0	0
LAO95	0	0	0	1	0
TNZ90, TNZ95, TNZ00, IND90K&S, UGA90, UGA95, UGA00	0	1	0	0	0
IDN95K&S	0	1	0	1	0

CASEID	TEN	DEMSUP	AGR	MACRO	OUTCOME -sensitivity
IDN00K&S, IDN05K&S, IDN10K&S, IDN15K&S	0	1	1	0	0
LAO00(0), LAO05(1)	1	0	1	0	C
TNZ05 (0), TNZ15 (1), JAVA90(1), UGA05(0), UGA10(1), UGA15(1)	1	1	0	0	C
TNZ10, VNM90, VNM95, VNM00, VNM05, VNM10, VNM15	1	1	0	1	1
JAVA00, JAVA05, JAVA10, JAVA15	1	1	1	0	1
LAO10, LAO15, JAVA95	1	1	1	1	1

Notes: '0' = enabling factor absent/smallholder tree growing area stagnant or decreasing; '1'= enabling factor present/smallholder tree growing area increasing. Abbreviations: LAO = Lao PDR; TNZ = Tanzania; K&S = Kalimantan and Sumatra; VNM = Vietnam; R = Remainder; C = Contradiction. The number after the country code indicates the reporting year.

Table 26. Truth table of remote conditions for sensitivity analysis of land tenure. Tenure [TEN] condition covering private and smallholder tree growing areas.

In this analysis, only land tenure (**TEN**) was necessary for the outcome. Instead, there were no contradictions in the configurations when the outcome was considered absent in Lao PDR and present in Tanzania and Uganda (see *Table 26* below). The estimated annual tree growing area increase in Laos became clearly visible after 2010 but the increase, when compared to previous years, was already significant in Tanzania and Uganda thus the latter option was used in the final analysis. The configuration formula for an outcome is described with Boolean algebra where '+'means 'OR' and '*' means 'AND'.

Configuration with the latter outcome is **TEN*DEMSUP;** i.e. tenure and demand are necessary conditions for smallholder commercial tree growing.

Value setting for the tenure security (**TEN**) required careful consideration and sensitivity analysis. In Laos, land security is a controversial issue: Land Law and Constitutional revisions have brought formal tenure security for land allocated under the village land use planning and land allocation process. However, people in northern Laos are especially still using land following the customary practices (e.g. for shifting cultivation) without formal tenure rights, which has led to land conflicts (e.g. in the process of concession area allocation). Tree growing is, however, mostly taking place on lands with formal tenure rights.

In Uganda private land ownership prevails and is strongly protected by the law with broad rights (for example, for land use conversion), but general awareness on the rights is low and there are regional differences in land tenure security. The government is incentivizing private tree growing by allocating degraded land from central forest reserves (CFRs) through 50-year lease agreements for tree growing. In general, it seems that tenure conflicts caused by weak law enforcement are more common in community forest lands than on managed planted forests. Land law is claimed to be ambiguous on lease arrangements, but the enthusiasm among private (smallholder) tree growers having grasped the opportunity to grow trees in CFR areas does not support this. In addition, tree growing incentive terms and conditions under the Sawlog Production Grant Scheme (SPGS) favour private landowners who have resources to invest money and capital to tree

growing, and likely also more capacity and knowledge to secure and protect their land rights.

Sensitivity analysis compared the outcome configurations considering: a) general land tenure security and land law enforcement (weak in both countries), and b) land tenure on lands where trees are grown (land tenure is generally strong).

The first analysis with overall land tenure situation produced contradictory configuration due to the Uganda case (years 2005, 2010 and 2015) and identified two configurations for necessary conditions (Table 25):

TEN + AGR*MACRO

i.e. tenure, or low agricultural pressure combined with favourable macroeconomic and policy environment were necessary conditions.

Table 25. Truth table of remote conditions for the sensitivity analysis of land tenure. Tenure [TEN] condition covering land tenure security in general in the whole country (Algorithm: Graph-based Agent)

CASEID	TEN	DEMSUP	AGR	MACRO	OUTCOME
LAO90	0	0	0	0	0
LAO95	0	0	0	1	0
LAO00, LAO05	0	0	1	0	0
TNZ90(0), TNZ95(0), TNZ00(0), K&S90(0), UGA90(0), UGA95(0), UGA00(0), UGA05(1), UGA10(1), UGA15(1)	0	1	0	0	C
K&S95	0	1	0	1	0
K&S00, K&S05,	0	1	1	0	0

CASEID	TEN	DEMSUP	AGR	MACRO	OUTCOME
K&S10, K&S15					
LAO10, LAO15	0	1	1	1	1
TNZ05, TNZ15, JAVA90	1	1	0	0	1
TNZ10, VNM90, VNM95, VNM00, VNM05, VNM10, VNM15	1	1	0	1	1
JAVA00, JAVA05, JAVA10, JAVA15	1	1	1	0	1
JAVA95	1	1	1	1	1

Notes: '0' = enabling factor absent/smallholder tree growing area stagnant or decreasing; '1'= enabling factor present/smallholder tree growing area increasing. Abbreviations: LAO = Lao PDR; TNZ = Tanzania; K&S = Kalimantan and Sumatra; VNM = Vietnam; R = Remainder; C = Contradiction. The number after the country code indicates the reporting year.

Analysis focusing on land tenure in tree growing areas included no contradictory configurations and identified two necessary conditions for the outcome (Table 26). An alternative solution - i.e. recoding all contradictory configurations as [0] on the outcome value - produces the same configuration for necessary conditions:

TEN*DEMSUP

Table 26. Truth table of remote conditions for sensitivity analysis of land tenure. Tenure [TEN] condition covering private and smallholder tree growing areas.

CASEID	TEN	DEMSUP	AGR	MACRO	OUTCOME
LAO90	0	0	0	0	0

CASEID	TEN	DEMSUP	AGR	MACRO	OUTCOME
LAO95	0	0	0	1	0
TNZ90, TNZ95, TNZ00, K&S90, UGA90, UGA95, UGA00	0	1	0	0	0
K&S95	0	1	0	1	0
K&S00, K&S05, K&S10, K&S15	0	1	1	0	0
LAO00, LAO05	1	0	1	0	0
TNZ05, TNZ15, JAVA90, UGA05, UGA10, UGA15	1	1	0	0	1
TNZ10, VNM90, VNM95, VNM00, VNM05, VNM10, VNM15	1	1	0	1	1
JAVA00, JAVA05, JAVA10, JAVA15	1	1	1	0	1
LAO10, LAO15, JAVA95	1	1	1	1	1

Notes: '0' = enabling factor absent/smallholder tree growing area stagnant or decreasing; '1'= enabling factor present/smallholder tree growing area increasing. Abbreviations: LAO = Lao PDR;

TNZ = Tanzania; K&S = Kalimantan and Sumatra; VNM = Vietnam; R = Remainder; C = Contradiction. The number after the country code indicates the reporting year.

However, land tenure rights and how they are enforced vary even within case-study countries between regions, land use forms, and socioeconomic contexts. Therefore, the chosen interpretation of the land rights for the final QCA covers the land rights of present and potential tree growers.

Ten (10) different combinations of contextual factors are observed out of the 16 possible combinations after the sensitivity analysis, leaving thus six (6) logical remainders (*Table 26*). Theoretically, all combinations can be considered possible, thus logical remainders are included in the analysis. Contradictory cases were not identified in this analysis.

The final configuration (based on Graph-based Agent algorithm) includes two necessary, in other words 'outcome enabling' factors.

TEN*DEMSUP

Upper-case letters denote presence of a factor and lower-case absence thus according to the analysis strong tenure rights and strong demand for wood must be present. No simplyfying assumptions were made in the process of reduction.

Table 27. Final truth table of Step 1

CASEID	TEN	DEMSUP	AGR	MACRO	OUTCOME
LAO90	0	0	0	0	0
LAO95	0	0	0	1	0
TNZ90, TNZ95, TNZ00, K&S90, UGA90, UGA95, UGA00	0	1	0	0	0
K&S95	0	1	0	1	0

K&S00, K&S05, K&S10, K&S15	0	1	1	0	0
LAO00, LAO05	1	0	1	0	0
TNZ05, TNZ15, JAVA90, UGA05, UGA10, UGA15	1	1	0	0	1
TNZ10, VNM90, VNM95, VNM00, VNM05, VNM10, VNM15	1	1	0	1	1
JAVA00, JAVA05, JAVA10, JAVA15	1	1	1	0	1
LAO10, LAO15, JAVA95	1	1	1	1	1

Notes: '0' = enabling factor absent/smallholder tree growing area stagnant or decreasing; '1'= enabling factor present/smallholder tree growing area increasing. Abbreviations: LAO = Lao PDR; TNZ = Tanzania; K&S = Kalimantan and Sumatra; VNM = Vietnam; R = Remainder; C = Contradiction. The number after the country code indicates the reporting year.

Sensitivity for step two (sufficient factors)

Sensitivity analysis for the second step focused on the different interpretations of incentives in the Lao PDR. The first option considers incentives being absent as the bureaucratic requirements make the incentives unattractive and unfeasible for smallholder tree growers, while the second analysis considers incentives being present as they are described in the laws and regulations. Sensitivity analysis (applying Quine algorithm)

on the direct (**DIRINC**) and indirect incentives (**DIRINC**) produced a small difference in the third configuration.

The configurations for the option 'incentives absent' are:

1) **TEN*DEMSUP*MAR*DIRINC** or,
2) **TEN*DEMSUP*KNOW*DIRINC** or,
3) **TEN*DEMSUP*know*dirinc*indirinc**

The configurations for the option 'incentives present' are:

1) **TEN*DEMSUP*MAR*DIRINC or,**
2) **TEN*DEMSUP*KNOW*DIRINC or,**
3) **TEN*DEMSUP*mar*know*dirinc*indirinc**

The comparison of coverage between the option shown in Table 28 demonstrates that in the 'incentives present' option the coverage of the third configuration is small compared to the other configurations, whereas in the'incentives absent' option the third configuration has slightly better coverage.

Table 28. Comparison of coverage between option incentives absent and incentives present in Lao PDR

Configurations	**Incentives absent**		**Incentives present**	
	Raw coverage	Unique coverage	Raw coverage	Unique coverage
KNOW*DIRINC*TEN*DEMSUP	0.60	0.10	0.60	0.10
know*dirinc*indirinc*TEN*DEMSUP	0.20	0.20		
mar*know*dirinc*indirinc*TEN*DEMSUP			0.1	0.1
MAR*DIRINC*TEN*DEMSUP	0.70	0.20	0.80	0.30

Note: Raw coverage indicates which share of the outcome is explained by a certain alternative configuration; unique coverage indicates which share of the outcome is exclusively explained by a certain alternative configuration.

One could also argue that trees are in some cases grown for other purposes than markets/to sell, for example to gain land rights. This may have also been the case in Lao PDR in earlier years, but the field research findings did not support this statement anymore. Also, slightly better coverage of

‘incentives absent’ option guided the decision to choose this option for the final analysis.

Appendix 5 - R-script for QCA verification process

The script used for the verification of the results with Tosmana is based on the work Oana and Schneider (2017).

```
library(QCA)
library(SetMethods)

## We set our working directory to the folder where we have our data:

SHdata <- read.csv("CountriesANNE.csv", row.names = 1)
SHdata

## New Two-Step Protocol

## Necessity of Remote Conditions

## 1. Necessity through parameters of fit

?QCAfit

QCAfit(SHdata[,5:8],SHdata$OUTCOME, necessity = TRUE)

## 2. Reinspect necessity through plotting:
```

```
xy.plot("DEMSUP", "OUTCOME", data = SHdata, necessity = TRUE,
jitter = TRUE)

## 3. 2x2 Table:

table(SHdata$DEMSUP,SHdata$OUTCOME)
table(SHdata$TEN,SHdata$OUTCOME)

?superSubset

superSubset(data = SHdata, outcome = "OUTCOME",
        conditions = c("TEN", "DEMSUP", "AGR", "MACRO"),
        relation = "necessity",
        incl.cut = 0.9)

## Second step of the 2-step QCA:

## Analysis of Necessity of Proximate Conditions:

## 1. Necessity with Parameters of Fit (PoF)

QCAfit(SHdata[,1:4], SHdata$OUTCOME, necessity = TRUE)

## Analysis of Sufficiency of Necessary Remote + Proximate:
## Building the Truth Table:
```

```
?truthTable

mySHTT <- truthTable(data = SHdata, outcome = "OUTCOME",
                     conditions = c("DIRINC", "INDIRINC", "MAR", "KNOW",
"TEN", "DEMSUP"),
                     incl.cut = 0.8,
                     show.cases = TRUE,
                     complete = TRUE,
                     sort.by = c("incl", "n"))

mySHTT

write.csv(mySHTT$tt, "mySHtt.csv")
# Conservative solution:

?minimize

SHcsol <- minimize(mySHTT, show.cases = TRUE, details = TRUE)

SHcsol

## Parsimonious solution:
```

```
SHpsol <- minimize(mySHTT, details = TRUE, show.cases=TRUE, include = "?")

SHpsol


## Intermediate solution (choose conditions which are theoretically guided):

## Having directional expectations about conditions:


SHisol <- minimize(mySHTT, details = TRUE, show.cases=TRUE, include = "?", dir.exp = "1,1,1,1,1,1")

SHisol


## Enhanced Intermediate Solution:

## Ban logical remainders that contradict necessity


mySHTTesa <- esa(mySHTT, nec_cond = c("TEN","DEMSUP"))

myTTesa


#2. Minimize - Intermediate solution


SH2isol <- minimize(mySHTTesa, details = TRUE, show.cases=TRUE, include = "?", dir.exp = "1,1,1,1,1,1")

SH2isol


pimplot(data =SHdata, results = SH2isol, outcome = "OUTCOME", jitter=TRUE)
```

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TROPICAL FORESTRY REPORTS

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No. 2	Salo, T. 1989. Study on export possibilities of mechanical forest industry products from selected Eastern and Southern African countries.
No. 3	Pietarinen, I. 1989. Agroforestry systems and intergrated land-use in the humid tropics.
No. 4	Johansson, S., Luukkanen, O., Kaarakka, V. & Mulatya, J. 1990. Forestry in irrigation schemes I. Research activities at Bura, Kenya 1984–87.
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No. 6	Sirikul, W. 1990. Shoot growth and flower development in tropical pines: Studies on genetic and environmental variation. Doctoral thesis (limited distribution).
No. 7	Luukkanen, O. & Hakulinen, M. (eds.) 1991. From Bangkok to the Blue Nile. Review of the first decade of the Tropical Silviculture Research Group 1980–1990 and abstracts of Research reports.
No. 8	Otsamo, A., Laxén, J., Johansson S., Kaarakka, V., Kuusipalo, J., Luukkanen, O. & Odhiambo Maua, J. 1993. Forestry research in Bura, Kenya 1984–1993. Final report of the research component in Bura Fuelwood Project.
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